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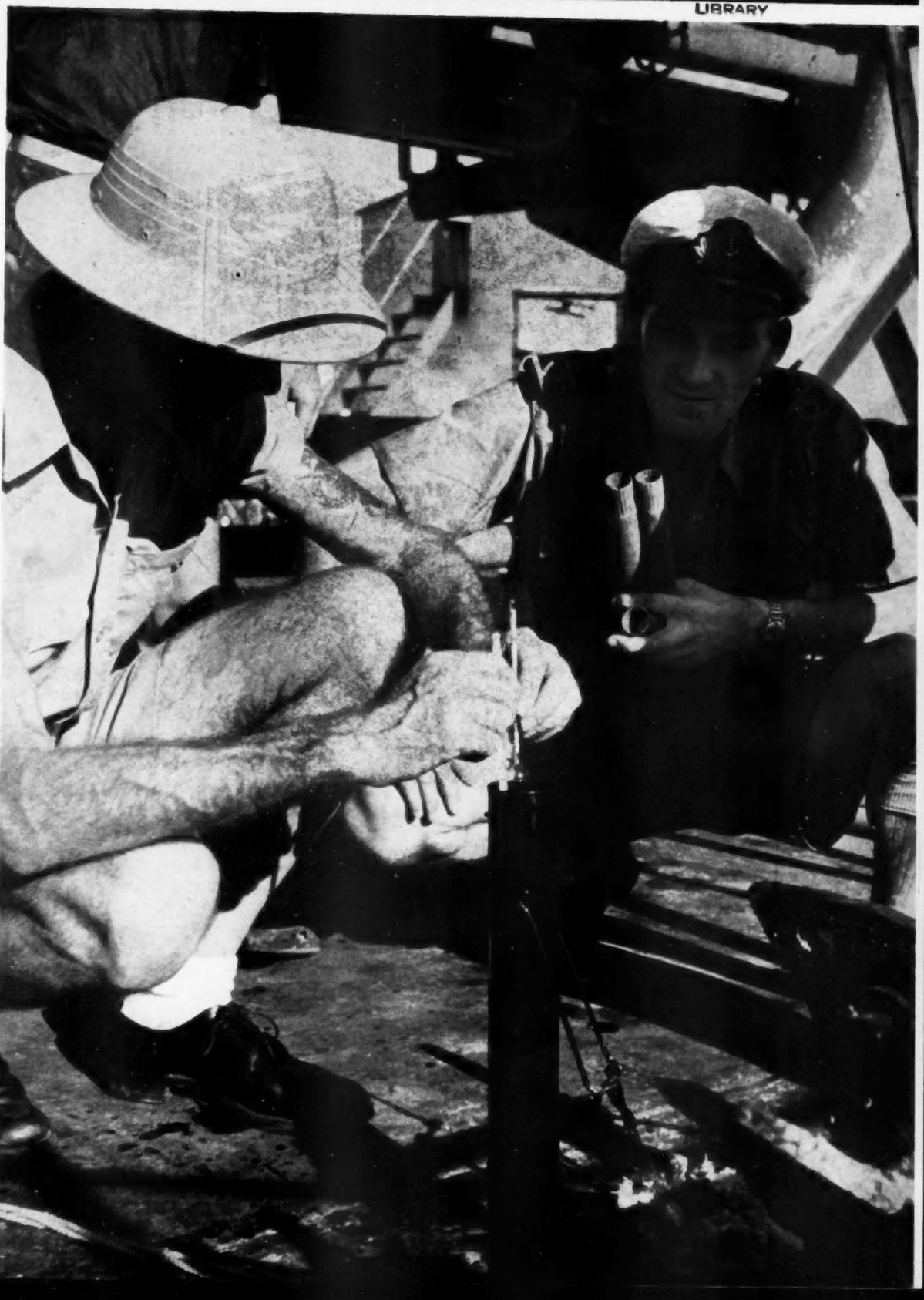

this issue

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High-Grade Vanadium Oxide
Alternator Winding Resistance Measured Under Load
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Is There a Shortage?

Is there still a shortage of engineers and scientists in Britain? Is it as easy as it has been for the past twenty years for a qualified man to slip into a new job whenever he wants to?

Suppose, for a moment, that a balance between supply and demand had been achieved, and consider what would be the appearance of this balanced state as shown by advertisements. Given continued full employment, there would still be substantially more advertisements than was usual before the war, simply because there is more engineering. The engineering industries now dominate the economy because they are the most effective users of educated men. There is little point in providing a state system of education, including university education for all who are able to benefit from it, unless the products of that educational system return a dividend when they go into employment. By going into the engineering industries the men who have been to university and technical college are best able to give a dividend because they help to raise the standard of living and earn foreign exchange. That is precisely what has been happening in recent years. More men have gone into engineering—taking engineering in its broadest sense, to include, for example, chemical and textile engineering and other industries which are engaged in the economic application of scientific discovery. The number of advertisements for scientific and engineering appointments is therefore bound to be greater to-day than it has ever been, quite apart from the relation between supply and demand.

Look also at the types of appointments which would be advertised when there is full employment, a strong leaning towards the technically based industries, and a condition of approximate balance in the supply and demand of technically qualified men. A high proportion of the advertising would be by firms and Government organisations which are (1) expanding, and therefore require more men, or (2) changing their products or techniques of production. The case of expanding organisations is clear-cut: they attract men from the declining industries, and to do this they have to advertise more or less continuously. Those which are changing their products or techniques require men who have specialised knowledge and experience, and they have to attract them from other firms or industries; these firms, also, have to advertise. Under the given conditions, therefore, advertising for technical men would be characterised by its sheer bulk compared with pre-war practice and by a high proportion of the advertising being for specialised qualifications. We can add to this conclusion two other factors which are particularly relevant at present: the fact that the aircraft industry, one of the largest employers of engineers and scientists, is going through a difficult phase of re-adjustment, and the fact that certain new techniques and equipments, such as automatic data processing and computers, inevitably demand men with unusual experience.

The amount and type of appointment advertising to-day corresponds with the situation which we have postulated: there is a good deal of it, and it is mostly to fill vacancies which demand special experience. It may well be, therefore, that a condition of balance between supply and demand has nearly been reached, taking the country as a whole. An industrial pattern which is continually changing, as ours is, requires that engineers and scientists should always be prepared to change the nature of their work. An electronics engineer who has worked on aircraft for the past ten years may have to move to electronic computers, for example. There must be flexibility in individuals as well as in firms.

A condition of near-balance does not, of course, imply that more engineers and scientists will not be required in the future. The Barlow Committee in 1946 and the Zuckerman Committee in 1956 envisaged a continual increase in the nation's requirements, as far ahead as it was prudent to forecast. The President of the Institution of Electrical Engineers, Mr. T. E. Goldup, was therefore right, at the Institution's dinner last week, to stress the urgency of future needs. (He said that the estimates of manpower for electrical engineering in 1970 were in fact likely to represent estimates of requirements four or five years earlier.) The estimates of the Zuckerman Committee were based on an average increase of industrial production at the rate of 4 per cent. per annum, and it is to be hoped that nothing will halt this increase. The bulge in school-leavers during the next few years will therefore present an unrepeatable opportunity to see that the numbers taking science or engineering at the universities continue to increase, without depleting the number of boys who go straight into apprenticeship in industry. No harm would come from over-production of scientists and engineers because the methods of science and engineering can usefully be applied outside the purely scientific or engineering fields.

Cover Picture. *In order to determine the amount of crude oil in the cargo of a tanker, it is necessary to know the specific gravity in each tank. The illustration shows this operation being carried out on a sample of incoming oil. The sillage is measured by the yardstick on the right.*

* * *

Plain Words

When I was a boy, building dams seemed a heroic humanitarian thing, mixed with high adventure. Later, when I helped to build a dam, I found I was mostly mixing concrete. However, by that time I had learnt to appreciate more practical matters and even batching concrete had its fascination. The adventure was there, but it was different from what I had foreseen. Even had I worked for the consultants and not the contractors I should still have been concerned with details and not with the overall concept of building a dam. How often are we drawn to some activity by an inspiration that the activity itself cannot properly sustain.

Conversely, there are people who take up some career because the work appeals to them and are subsequently promoted to other duties which on the surface at least seem less appealing. Physicists and engineers engaged on problems of research may find as their careers proceed that they devote less and less time to scientific and technical matters and more to questions of administration. However exciting they may find the new routine, they are always likely to remember, perhaps nostalgically, the experimental work on which they once were occupied.

In both these cases the difficulty is to see the grand picture, the all-embracing purpose of a job. Perhaps more than anybody the administrator has this comprehensive view; but even for him the clarity is spoiled by a myriad day to day decisions, which must to some extent mar his vision. In any case, by the time the lucky few reach places of high responsibility, they themselves have changed; no longer do they see the world with a schoolboy's sense of wonder.

Attention to detail and a discernment that cuts through detail are qualities not easy to combine. Too often the details of our work conceal its meaning; too often the wood lies hidden in a mass of trees. Remoteness allows us to see things in perspective; but also it gives an added beauty to the view. Music carried on the wind or heard in another room has a quality which often disappears when nothing is left to the ear's imagination. Similarly, too close a study of any subject may deaden the student's natural interest. Schoolchildren asked to list metaphors in *Paradise Lost* may never again enjoy a poem. Musical erudition can sometimes hide the tune. I would rather think of a passage of music as a lark ascending than as an exercise in counterpoint or harmony.

Yet in spite of long and detailed acquaintance with music, most musicians retain their feeling for its spirit. Like them, we must come to identify the vision with the fact.

CAPRICORN

Weekly Survey

The Whole Truth

When Professor Werner Heisenberg stated last week that he and his colleagues had developed an equation that served to reconcile all branches of physical science, he may well have introduced a new phase not only in scientific but also in technical thinking. Speaking in Göttingen, he said that he could not yet prove the validity of his formula, but if confirmed it would provide the basis of a unified field theory. Use had been made of the work published last year showing that the law of parity was not invariably true. (See ENGINEERING, page 538, April 26, 1957.) He summarised his lecture in the following words: " Leibniz said that this is the best of all possible worlds. I do not entirely believe that, but it does seem that ours is the simplest of all worlds."

Attempts have been made by many, including Einstein, to fit electrical, magnetic and gravitational phenomena into a single all-embracing concept, but until now only partial success has been achieved. Professor Heisenberg, who is noted for his work on quantum mechanics (Nobel Prize 1932) and on ferromagnetism, and for his famous " uncertainty principle " (the position and velocity of a particle cannot be measured accurately simultaneously), appears to have solved the problem that has troubled physicists for more than 30 years.

A body is said to exist in space and time, but is also subject to the influence of gravitational and electromagnetic fields. Einstein in his general theory of relativity depicted gravity as a configuration of space time, thus relating three of the five terms. Professor Heisenberg has apparently brought the last two—electrical and magnetic fields—into one system.

Such an achievement might seem merely a remarkable feat of mental gymnastics, of interest only to physicists and mathematicians, but if we consider the effect that similar syntheses have had in the past, it will be apparent that engineers and humanists too will have good cause for reflection. When Newton sought to reconcile the observed motion of the planets and of bodies here on earth he evolved a set of simple equations that wrought dramatic changes in practical affairs. Without Newton's laws of motion it is reasonable to suppose that modern engineering could never have existed. A consequence of Einstein's theory of relativity, which reconciled the cosmic with the microscopic, is the equation $E = mc^2$, showing the equivalence of mass and energy, with the square of the velocity of light as the conversion factor—an equation on which the exploitation of nuclear energy is based.

Without detailed knowledge of Professor Heisenberg's equation, it is impossible to judge its implications, though it prompts some exciting if risky speculation. A theory embracing gravity and electromagnetism would appear to apply in such disparate fields as that which has been called nuclear fusion (since mutual electrostatic repulsion tends to keep the nuclei apart), and astronautics (though electromagnetic anti-gravity devices are of course already familiar to those who work in metal scrap yards). Idle though such conjecture may seem it does at least indicate the scope of such a theory.

Much of practical importance has followed from the work of Newton and Einstein, though their results embraced only certain regions of physical science. A unified field theory, being within its terms of reference the whole truth, surely holds even greater promise.

Around the Commonwealth

A Commonwealth Engineering Conference is to be held in Australia this month. It will be attended by the presidents and secretaries of the three senior engineering institutions in this country. The meetings will be held in Sydney, Melbourne and Canberra.

A feature of the expedition will be the visit of the party to overseas groups of their members in the Middle and Far East. After the conference, the party will visit similar groups in New Zealand and Canada. By the end of April, they will be in New York for a meeting of the Conference of Engineering Societies of Western Europe and the United States. After this meeting some members of the party will visit the joint overseas groups of the three institutions in Trinidad and Argentina while others will attend the annual dinner of the General Engineers' Institution in Canada at Quebec.

This world tour is of considerable professional interest. It represents in the first place an organised international exchange of views and technological information among senior professional and scientific bodies in Europe and America. It also represents an effort on the part of the United Kingdom institutions to break down the professional isolation of their overseas members. It is to be hoped that this tour is the beginning of a new development in professional engineering.

Automation Approved

As reported on page 319 in this issue, 21 institutions representing all the major engineering industries and allied technologies have recently set up a " British Group for the Engineering Applications of Automation," under the auspices of the British Conference on Automation and Computation. The primary purpose of the group, as its title indicates, is to foster the development of the engineering applications of automation. It furnishes a common meeting ground for member organisations and provides for co-ordinating and extending their activities in the engineering-automation field. The Group will also keep in touch with the two other groups which form the British Conference—one of which is concerned with computation and automatic control, and the other with the sociological and economic aspects of automation techniques. The group intends to encourage British participation in international conferences and, through the general British Conference committee to maintain liaison with the corresponding committees of other countries.

The elected officers of the Group for the Engineering Applications of Automation are: chairman, Dr. D. F. Galloway, M.I.Mech.E.; vice-chairmen, Mr. J. S. Brough, M.I.Mech.E., M.I.Chem.E., and Sir Walter Puckey, M.I.Prod.E., F.I.I.A.; honorary secretary, Mr. Brian G. Robbins, M.I.Mech.E. Secretarial services for the Group are to be provided by the Institution of Mechanical Engineers (of which, as is well known, Mr. Robbins is secretary). The chairman and vice-chairmen will all attend the general conference committee.

Some idea of what the Group will be doing emerges from the subjects discussed at their first meeting on February 20. They propose that (if the Computation and Automatic Control Group agree) a symposium on instrumentation and computation in process development and plant design, being planned by the Institution of Chemical Engineers, the Society of Instrument Technology, and the British Computer Society, should be held under the aegis of the British Conference. They discussed the possibility of taking part in the Fourth International Exposition and Congress on Automation to be held in New York in June; relations with the International Federation of Automatic Control and other organisations; the publication of a bulletin; and the need for a bibliography. Clearly, automation as a word and as a study, has now been properly approved.

Licensed Aircraft Engineers

There will be a good deal of sympathy with the proposals put forward by the Society of Licensed Aircraft Engineers in the January, 1958, issue of the S.L.A.E. *Journal*. They have the object of enhancing airworthiness standards by increasing the proportion of qualified engineers serving the operation, maintenance, overhaul and repair of civil aircraft registered in the United Kingdom. Opponents of the proposals may, however, retort that the society have over-emphasised the shortcomings of the present system in the interest of their members, a charge which the general council of the society clearly foresaw, since they stated that they were " very conscious of the fact that the traditions and sentiments inherent in their own and the society's membership could influence their decision."

In their report, which has been submitted to the Minister of Transport and Civil Aviation, the Air Registration Board and other authorities concerned, the general council say that although it is difficult to prove because engineers aware of the facts are afraid of victimisation and will not substantiate the evidence in writing " there are but few senior members of the Society of Licensed Aircraft Engineers who are not well aware of the shortcomings of certain approved inspection organisations, the general fall in the standards of workmanship within many operating companies in recent years, and the number of accidents that nearly happen, or could easily have happened because of faulty engineering."

A statement of this nature by a responsible organisation certainly requires detailed investigation. Consideration is also necessary of the best methods of ensuring that repair and maintenance work are carried out to the required standard of safety since the procedure varies a great deal from one country to another. Meanwhile, the Society of Licensed Aircraft Engineers have produced detailed proposals for developing the Aircraft Maintenance Engineer's Licence as a qualification and for restricting the certification of the rectification of defects to licensed engineers holding appropriate " type endorsements " from the A.R.B. or " type approvals " from the chief inspectors of approved inspection organisations.

Service from Machine Tools

Some interesting facts regarding machine-tool production are given in *The British Machine Tool Industry*, a statement published last week by the Machine Tool Trades Association. The industry has been the subject of some criticism in recent years for failure to expand production sufficiently to prevent long delivery delays, but the statement shows a steady increase in output from £66 million in 1954 to £75½ million in 1955, £85½ million in 1956 and £48½ million in the first six months of 1957. Between 1948 and 1957 capital employed in 115 representative machine-tool companies rose from £25½ million to £78½ million, while over this period new machinery, plant and equipment were installed to a value of £21·4 million. A further expenditure of £9·6 million is contemplated by 1960.

After drawing attention to the growing specialisation within the industry, the statement discusses export and import policy. It claims that the prime function of the machine-tool industry is to serve the overall productive efficiency of British industry as a whole. Since the war, exports have averaged about 30 per cent. of production, and from time to time discussion has arisen as to whether the industry should attempt markedly to expand exports, thus in many cases assisting other branches of the engineering industry overseas to become more competitive with British industry, or should be content with a marginal level of exports. The statement argues that home industry alone cannot support a machine-tool industry large enough to be both versatile and forward looking. The industry's output target therefore aims at meeting normal home demand and maintaining maximum exports, but since home demand fluctuates considerably this implies that abnormal home demands must be met by imports. This permits the industry to claim that it serves the overall productive efficiency of this country by giving the user of machine tools access to the product which suits his purpose or his taste, irrespective of the works or country of its origin.

Physical Re-adjustment

Times change, and with them not only fashions but actual needs as well. Bodies who do not keep up with the times soon lose their usefulness. It is therefore good to note that the National Physical Laboratory are to make certain changes as a result of a review made of their work and organisation by a committee of the Research Council of the D.S.I.R. These changes will become effective about the end of March.

One of the more important is the re-organisation of the work now carried out in the divisions of electricity, metrology and physics and in the test house. These four units are to be replaced by three new divisions to be called " standards," " applied physics " and " basic physics." Standards will be concerned with fundamental work on length, mass and times, as well as electricity, magnetism and temperature. Applied physics will deal with items likely to be of immediate value to industry (excluding optics), and basic physics with " certain branches of non-nuclear physics which have potential industrial applications in the less immediate future."

A new post recommended by the Research Council, that of Deputy Director, has been filled by the appointment of Dr. Edward Lee who is at present director of operational research, Royal Naval Scientific Service. He will take up his duties on March 31 and will take the main responsibility for work in the laboratory which is closely geared to immediate demands from industry.

It is hoped that these changes will make the work of the N.P.L. more readily available, and possibly more directly useful to the present needs of industry. A man with long experience in operational research, and in relating research programmes to the staff available, should be a great asset in these days of scientific manpower shortage.

Storing Documents

The French National Archives occupied about 13 km. of shelving just over one hundred years ago and needed 13 keepers. To-day there are 240 km. to look after (in distance as far as from Paris to Brussels) but only 24 keepers are employed. How this prodigious rate of growth has been made physically manageable with so modest an increase in archivists is told in the latest (No. 28, February, 1958) issue of the European Productivity Agency's magazine, *European Productivity*.

The rate of expansion is still rapid. Another 100 km. of shelving are needed as soon as possible. Furthermore, the advantages of centralised archives have recommended themselves to such nationalised organisations as the Renault Corporation and Electricité de France. There is therefore growing pressure on storage capacity from sources other than Government departments.

One major improvement has been to replace old wooden shelving with metal shelving. By using a system of pivoting shelves it was possible to increase a given storage space by 40 per cent. This could be done by having quadruple instead of double (back-to-back) rows of shelves which achieved a major space economy with a reduced number of corridors although the corridors had to be widened individually to make pivoting possible. Micro-filming has been used to some extent also.

Letters to the Editor

TESTS ON SOIL

SIR, I was most interested to read the review of my book on *Laboratory Testing in Soil Engineering*, published on page 252 of your issue of February 21.

Your reviewer has pinpointed one of the difficulties in writing and publishing any technical book, and especially one on a subject, such as soil mechanics, which has been growing rapidly in the last few years and in which many changes in the technique of testing have occurred.

In a book such as mine no purpose is ever served by omitting tests, and its value is always increased by the inclusion of the latest information and descriptions of the most up-to-date procedures. I would like to assure you that at the time when the book was written it incorporated every latest development of which I was aware, and not only those produced in the laboratory of Soil Mechanics Limited.

Yours faithfully,
T. N. W. AKROYD.

Sidcup, Kent.
February 27, 1958.

BRITISH ENGINEERS

SIR, When, in your issue of July 26, 1957 (page 102), you published under the title " Why was George Stephenson not a Member of the 'Civils' ? " an abbreviation of my article " A Study of an Alleged Slight," I was not in a position to comment on the letters in your columns by Mr. R. H. Parsons and Mr. Rex Wailes defending Samuel Smiles' story, printed in some editions of his books on the Stephensons, that Stephenson had been refused admission to the Institution of Civil Engineers.

Frankly, I had hoped that one of your correspondents might have been able to throw some conclusive light on this story, which has no support from the archives of the Institution of Civil Engineers, nor presumably, from those of the Institution of Mechanical Engineers. Indeed, when subsequently undertaking the research for this summer's Telford Exhibition, the unwisdom of accepting Smiles, even on purely engineering questions, was proved on several occasions.

With those who maintain that the history of the past is not of significance to the present, I disagree. Even if the " Study of an Alleged Slight," which is still available from the Institution of Civil Engineers, does nothing else, the abundant comments it contains in the words of engineers of the time throw George Stephenson's character into relief, showing him as the infinitely determined man without whom Britain might never have pioneered the construction of railways for this country and the world.

The friend of Prime Ministers and the adviser of Kings, Stephenson fulfilled in a superlative way the role which British engineers are playing in the world to-day as ambassadors of their country and founders of prosperity in under-developed lands. It is seen in this light that magnification of a trivial and uncorroborated anecdote in which even Smiles had not sufficient faith to place it in all the editions of his works, seems to be a disservice to the profession as much as to Stephenson himself.

Following the comparatively uneventful period between the wars, engineers are again being called upon to provide the leadership for something in the nature of a second industrial revolution. A study of Stephenson, Telford, and other great engineers, makes clear the qualities which are required of them, and should re-assure them that their tribulations of the present though possibly new in form, are identical in character.

An interesting innovation which has accompanied this revival of interest in engineering, has been the Institution of Civil Engineers' experiment in making the details of engineers' work, both past and present, more widely available to the public by means of the Press, radio, and television. The forbearance and patience of

Continuing Letters to the Editor

leading engineers in dealing in this unfamiliar medium of disseminating knowledge has been matched by the courtesy and heightened interest of the Press, and has frequently resulted in the return of important information through correspondence, and through comment in newspaper columns.

It is to be hoped that other engineering Institutions will speedily follow the lead which has been given, and place their quest after scientific knowledge on a similarly wide basis. Certainly, they would reap the gratitude of a world thirsty to know just what British science and engineering is able to offer.

Yours faithfully,
D. W. SELBY.

40A Paultons-square,
London, S.W.3.
February 21, 1958.

Editor's Note: The letters from Mr. R. H. Parsons and Mr. Rex Wailes, referred to by our correspondent, appeared on page 165 of our issue of August 9, 1957.

COMPUTERS AT NEWCASTLE

SIR, May I refer to the note published on page 254 of your issue of February 21 and headed "Computer for Heavy Electrical Design?" Your reference to the Pegasus computer already installed in Newcastle upon Tyne may, perhaps, be amplified, since this computer is not the property of King's College, Newcastle, but of the University of Durham, which is technically and legally an institution of which King's College forms the major part. The University Laboratory is housed at Newcastle upon Tyne because it seemed more appropriate that it should be there rather than in Durham, but it is equally available to members of both divisions of the university.

Yours faithfully,
E. M. BETTENSON,
Registrar.

University of Durham.
February 24, 1958.

VICKERS SCHOLARSHIP

SIR, In your issue of January 10 (page 45), you made generous reference to the University Scholarship awarded by the Vickers Group of Companies, but the awards are, in fact, a little different from the pattern indicated in your note. The Vickers Cambridge scholarship is available to boys who have not yet joined the company but who, after the award is made, spend one year in the works and a further year after graduation. In addition, each of the three member firms of Vickers-Armstrongs, Limited, namely, shipbuilding, engineering and aircraft, make a major award, and seven other slightly less valuable awards are available group-wise. Then come the two supplementary awards, amounting to £100 each, to a scholarship winner. This is not the whole story, for each general manager is authorised to sponsor any other worthwhile apprentices at university or technical college sandwich courses.

Yours truly,
C. L. OLD.

Vickers Limited.
January 14, 1958.

YORKSHIRE IMPERIAL METALS LTD.

We would like to clarify the report of the new company, Yorkshire Imperial Metals Limited, which we published on page 239 of our issue of February 21. We referred there to I.C.I's "newly acquired subsidiary, Yorkshire Copper Works Limited," but the use of the word subsidiary is an error for which we apologise. The facts are that an entirely new company has been formed, with only two shareholders—Yorkshire Copper Works (Holdings) Limited (the name of the old company having been changed), and Imperial Chemical Industries Limited, each holding equal shares and each nominating the same number of directors.

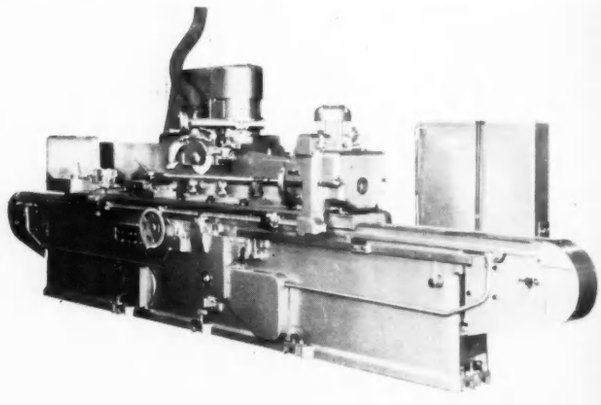
Plant and Equipment

SPLINE GRINDING

The machine illustrated below, a 72 in. spline grinder made by A. A. Jones and Shipman Limited, takes its nominal size from the distance between centres. It has a working stroke of 84 in., and a useful grinding length of 66½ in. With a centre height of 7 in. and a wheelhead vertical adjustment from 3½ in. to 11½ in., the machine will grind from zero work diameter with a wheel worn to 7 in. diameter, or 13 in. work diameter with a new 10 in. wheel. A wheelhead feed handwheel gives a vertical feed of 0·05 in. per revolution, and there is an additional fine feed arrangement graduated to give wheelhead movements of 0·0001 in. There is an axial movement of ½ in. of the wheel spindle, with dial indication, to provide a fine side feed motion.

Hydraulic traverse, up to 60 ft. per minute, is provided for the table, which mounts an indexing workhead, with its own self-contained hydraulic unit for indexing. Indexing accuracy is achieved by means of a notched plate and a pivoting indexing pawl. There are 48 notches provided as standard, and by means of standard masking plates the indexing head can give 48, 24, 16, 12, 8, 6, 4, 3 or 2 positions. Other indexing sequences are available as extras.

The main hand control is a combined "start-stop," speed control and hand traverse engagement lever of joystick pattern.



Splines up to 66½ in. long, on shafts up to 13 in. diameter, can be ground on the Jones-Shipman 72 in. machine.

TRAILERS TO FOLLOW A TRACTOR'S PATH

A problem facing the Hydraulics Research Station of the D.S.I.R. was the conveyance of building materials along the tortuous passages between the tanks containing the river models. These passages are frequently only 4 ft. wide for a height of 30 in. and often have very sharp bends as they follow the curves of the rivers.

To meet the problem, a pneumatic-tyred trailer was developed, a series of which could be hauled behind a small industrial tractor and which would follow the tractor's path very closely. The trailers' chassis were built by Lansing Bagnall, Limited, and incorporated that firm's four-wheel steering mechanism. The bodies were ¾ cub. yd. skips taken from some Robert Hudson narrow-gauge railway trucks.

The wheelbase of the trailers is 6 ft. 4 in. and the track is 3 ft. This gives an overall width at the tyres of 3 ft. 7 in., and at the top of the skip of 4 ft. 6½ in. The overall length is 8 ft. 4 in. When hauled by a tractor supplied by the Mercury Truck Company the turning circle for a train of four trailers is 21 ft. and the complete length is 40 ft. Under these conditions the last vehicle follows the path of the tractor to within 1 in.

PRECISION VACUUM OVEN

The Gardiner vacuum oven designed originally for the determination of solids in such labile products as syrups and molasses containing fructose, is now being made by Griffin and George Limited, Ealing-road, Alperton, Middlesex. The standard form is shown below.

The sample under test is taken into solution and distributed over an aluminium powder extender in a sample dish. It is then heated under a partial vacuum while a little dry air or inert gas passes over it. Heat is provided by 12 refractory elements inserted symmetrically in the heating block. Two heat loads are available, 70 or 160 watts, both of which are symmetrically distributed. The oven measures 17½ in. by 17 in. by 12½ in. deep. An air bleed drying train of three glass U-tubes, containing activated alumina, and a horizontal tube of barium oxide reduce the water content of the incoming air to 0·000 7 mg. per litre.

Gardiner vacuum oven for precise measurements.

The heating block is cadmium plated mild steel 9 in. in diameter and 1⅛ in. thick. A bi-metallic thermostat, adjustable up to 110 deg. C., controls the temperature to within 1 deg. Six sample dishes may be placed in an annular groove in the block and there are six corresponding air inlets. The incoming air is projected on to the roof immediately above the dish and out through a central control spigot to a metal desiccator containing phosphorus pentoxide. O-ring seals are used and vacuum sealing at the centre spigot is obtained by a soft metal washer under the wing nut. The air flow to the chamber can be controlled between 0·5 and 100 ml. per minute and is measured by a soap film flowmeter.

CONTINUOUS CASTING OF STEEL

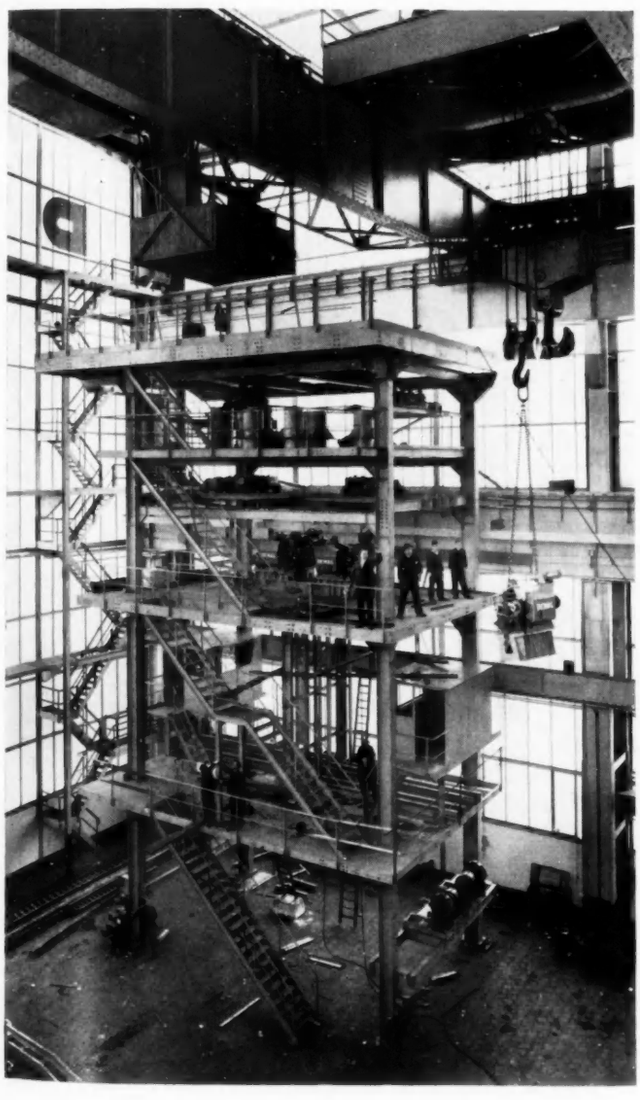
German-built plant has yearly output of 200,000 metric tons

If molten metal is poured into an open-topped mould and then, when the metal surface in contact with the mould walls has solidified, the resulting casting is drawn from the bottom of the mould at a controlled rate, it is possible to continue pouring liquid metal at the top and drawing away a casting at the bottom. The rate of pouring and withdrawal being adjusted suitably, the production of a billet, round, slab or other semi-finished product becomes continuous, and there is no theoretical limit to the length of the cast, which can be cut into pieces as required, by some suitable cutter travelling with it like a flying shear. By using this process it is possible to dispense with some of the costly capital equipment necessary for the production of billets and similar sections by traditional means. Continuous casting, therefore, has some important advantages, and it is not surprising to find that an increasing interest is being taken in the subject.

The process is actually much older in conception than is generally realised, having been first suggested by Bessemer about a hundred years ago. Little practical was done, however, until the German S. Junghans succeeded, in the 1920's, in applying the principle to the continuous casting of non-ferrous metals, a field in which it is now used extensively. Experiments with steel followed, and by about 1945 this metal had been cast successfully. In 1950 Mannesmann-Hüttenwerken, A.G., Duisburg-Hückingen, and Gebr. Böhler and Co., A.G., Kapfenberg, Austria, began to develop the Junghans system co-operatively, and a few years later Demag, A.G., Duisburg, purchased the world manufacturing rights. Steel casting plants on this system are in operation in Germany, producing a variety of sizes and cross-sections, ranging from rounds to slabs, and in numerous steel analyses. Experience has shown that both for finish-rolling and for the production of drop forgings, the billets and other cast sections are perfectly satisfactory and are, in fact, impossible to distinguish from those made by conventional methods.

Demag have now completed their first multi-strand plant for the continuous casting of steel on a large scale. Built to the order of Terni Società per l'Industria e l'Ettricità, Terni, Italy, the plant has eight identical casting units or strands, for producing billets 110 or 140 mm. (4·3 or 5·5 in.) square, at speeds of up to 2·5 metres (8·1 ft.) per minute, the length of the billets cut from the continuous cast being up to 3 metres (9·8 ft.).

The plant is designed as a pair of identical sections, each with four strands, and erected together to form the complete equipment. When it is taking the output from two 60-70 ton open-hearth steel furnaces, all eight casting strands will be in use; when the steel is taken from two 35 ton electric arc furnaces, four of the strands will suffice. Total output will be 180,000 to 200,000 metric tons a year.



Steel billets are cast continuously in eight strands and cut off to length in the Demag continuous casting plant. Shown during shop erection is one-half of the complete plant, containing four casting strands.

A free-standing structural steel tower carries the plant, the overall height of the structure being 18 metres (60 ft.), of which 4·8 metres (16 ft.) will be below, and 13·2 metres (44 ft.) above ground level, on site. There are five platforms or floors and two control points, one at the top for casting the metal, and the other lower down for the equipment which cuts off the billet lengths.

On the top or fifth floor, from which casting is controlled, there is a long gas-heated pouring launder or "tundish" with spouts leading off to the two lines of casting strands, which are arranged one on each side of the tundish. Steel brought by conventional bottom-pouring ladle is teemed into the tundish and flows from it to the casting strands. Provision is made for dealing with a possible runaway stopper on the ladle, which would prevent the flow of steel being controlled. Should this happen an overflow conducts the molten steel away to a point where it can be dealt with by a pig-casting machine or any other suitable means. The long tundish can be moved a short distance along the line of strands to bring the spouts clear of the mould tops when required.

Each of the moulds is of copper, with hollow walls, water cooled, and in its internal dimensions slightly over the required finished billet size, to allow for cooling contraction. Immediately below the mould is a set of idle rollers, completely surrounding the cast as it emerges, to give support to the thin solidified skin, while water sprays, directed between the rollers, cause further solidification. Each of the casting strands requires 150 litres (33 gallons) of water per minute, the total cooling water requirement being, therefore, 1,200 litres (264 gallons) per minute. Of this total, the mould water, which rises 10 to 12 deg. C. in its passage through the mould, is wholly recoverable by cooling and re-circulation if required. The spray water, which undergoes a temperature rise of 25 to 30 deg. C., suffers a 25 per cent. loss by steam, and the remainder, if re-used, must be cleared of scale before re-circulation. Water availability and cost at site dictate the method employed.

MOULD RECIPROCATION

Moulds, support rollers and water sprays are all reciprocated by power while casting is in progress, to prevent any possibility of the solidifying metal sticking to the mould walls. A separate electric motor and infinitely-variable speed gear, working through levers and an adjustable-throw eccentric, is provided for each of the eight strands, and the stroke can be varied from 0 to 25 mm. (1 in.) at 30 to 100 strokes per minute. All the mould reciprocating machinery is housed on the fourth floor.

Below the mould reciprocating gear, on the third floor, are eight 2½ ton electric hoists, push-button controlled from the second floor, which serve the casting strands when it is necessary to lower the end of a cast as pouring is stopped, or for raising plugs to the bottoms of the moulds when starting up.

On the second floor are the traction rolls, one set per strand, which are electrically driven and hydraulically loaded to give the necessary traction pressure. They are normally employed to give a downwards motion to the cast and draw it continuously from the mould, but the driving motors are reversible to allow dummy lengths of billet to be fed upwards to start a cast.

The first floor accommodates the cutting-off gear and the cabins from which the billet-cutting operations are controlled. Part of the equipment for starting a cast is on the first floor.

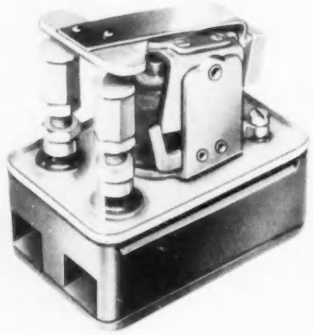
Cutting of the downwards moving cast is by means of swivelling oxy-acetylene burners, one for each strand, moving on carriages synchronised with the cast by means of heavy chain connections from the traction roller drive gear above. As each length of billet is cut off it is seized by a hydraulically-operated grab, and drawn downwards at about twice the speed of the cast, into a fabricated steel pocket at the bottom or pit floor level. This pocket turns through 90 deg. and lowers the cut billet for disposal horizontally.

Once a length of metal has skin-solidified in the mould it can be drawn downwards, and the process is continuous, but it is obvious that some means of closing the bottom of the mould temporarily must be provided to start casting. This is done by means of a steel plug 15 cm. (6 in.) long and 6 metres (19·6 ft.) of dummy billet; the dummy is split into two equal lengths for convenience in handling.

To start operations a plug is fixed to the top of the first length of dummy billet, and drawn up by means of the electric hoist until the traction rollers can grip the dummy. The second length is then fixed to the first, and the plug is

Continuing Plant and Equipment

pushed up to the bottom of the mould. When all the moulds are stopped in this way, casting commences, and the traction rollers draw the dummy downwards, the cast following it into the rollers. Quick-release couplings are used on the dummies and plugs, and the dummies are provided with short wings extending on two sides. As the dummy is lowered, it passes through a spring-supported open box on a small railcar on the first floor. As soon as the top of the lowest section of the dummy is about ½ metre (20 in.) from the box on the car, the coupling is released, and the section falls free, to be caught and retained in the box by its wings. The car is then traversed quickly to bring the second, empty box in line with the remaining piece of dummy cast, and the process of uncoupling is repeated, to leave the top half of the dummy suspended in the box. The car is then traversed quickly to one side, where it is parked, holding the two dummy sections ready for use when required. The plug passes through on the end of the first billet, and is cut off later for re-use.



AIRCRAFT RELAY

Shown in the illustration above is a 60 ampere bridging make relay designed to withstand severe conditions of shock, vibration, humidity and altitude—one of a range of relays developed for the aircraft industry by the Plessey Company, Limited, Ilford, Essex. Operating over an ambient temperature range of − 65 deg. to + 70 deg. C., the relay is available in two forms, hermetically sealed or dust-proof, both versions having identical mechanisms. In common with other Plessey relays in the range, it is built with a balanced armature so that correct operation is not affected by vibration or acceleration. Additionally, the bridging contacts have a wiping action, thereby minimising contact resistance.

The hermetically-sealed version weighing 10½ oz., 1 oz. heavier than the dust-proof version, has a moulded terminal shroud and detachable terminal cover. The terminals of the dust-proof type are accessible by removal of the dust cover. Overload capacity which is wound for 28 volts direct current, is 480 amperes d.c. at 60,000 ft. or 600 amperes d.c. at lower altitudes, non-inductive. The hermetically-sealed version does not depend upon the perfection of sealing for this overload capacity.

At normal rated current, subject to certain limitations regarding the inductive nature of the controlled circuit, the relays are capable of a minimum of 100,000 operations make and break. Moreover, the hermetically-sealed version is flameproof and climate proof to D.T.D. 1085 B.

Automobile Engineering

THE GIPSY

Austin's New Light Utility Vehicle with 4-wheel Drive and All-Independent Suspension

The Gipsy, just announced by Austin, is a light 4-wheel drive utility vehicle with all-independent suspension and a choice of petrol or Diesel engines. The all-steel body, with folding top, has space for three people on the front seat and a further six seats can be fitted in the rear. It is a lighter, less complicated job than the Champ, Austin's previous venture in this field, and the body is more practical for civilian use.

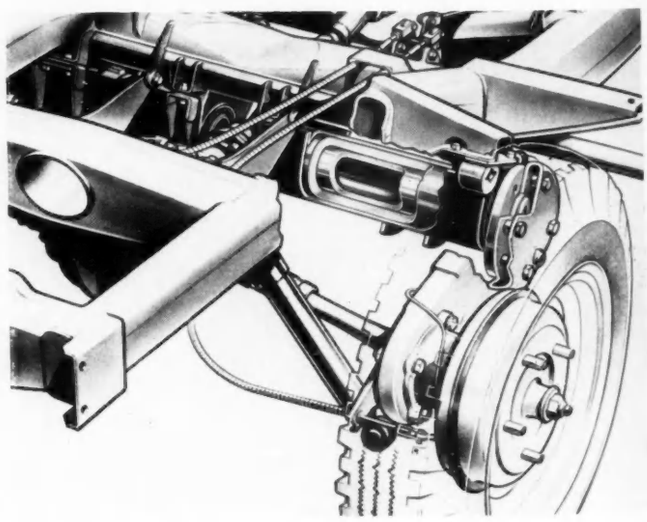
The chassis is of steel pressings seam welded to form tubular side members and six cross-members. Each wheel is carried on a single deep trailing arm of box section pivoting on a transverse torsional rubber suspension unit made under Flexitor patents. Piston dampers are used at the front, and telescopic dampers at the rear. The all-steel body has two side doors and removable tail board. The folding two-pane windscreen has an electric wiper on the driver's side and the instrument panel is hinged for access to the electric wiring. The front seat is in foam rubber covered with plastics and the folding top is in leather-cloth, coated with polyvinyl chloride.

The petrol engine is a four-cylinder pushrod unit with the same stroke as the engine formerly used in the Champ and the Austin-Healey sports car, but a smaller bore giving 2,199 c.c. (134·1 cub. in.). It produces 62 b.h.p. at 4,100 r.p.m. and a torque of 110 lb.-ft. at 1,500 r.p.m. The alternative Diesel engine has a larger bore and shorter stroke, giving 2,178 c.c. (132·7 cub. in.) and delivers 55 b.h.p. at 3,500 r.p.m., with peak torque of 89 lb.-ft. at 2,800 r.p.m.

Transmission is through a single plate dry clutch (9 in. diameter for the petrol engine; 10 in. for the Diesel) to a four-speed gearbox with synchromesh for the upper three ratios. On the rear end of this box is mounted a transfer box which gives four ratios direct to the rear wheels, or four ratios through a step-down to all four wheels. Open propeller shafts take the drive to pressed steel differential cases mounted on the chassis. Hydraulic brakes on all four wheels have drums of 10 in. diameter 1¾ in. wide, giving a total friction lining area of 133 sq. in. The hand brake works through cables on the rear wheels only. Steering is cam-type and the electrical system is 12 volt. Instruments are speedometer, ammeter, fuel gauge and oil pressure gauge. Optional extras include mechanical tyre pump, power take-off from the transfer box by shaft to the rear of the vehicle or by pulley in the centre, and seats for six in the rear compartment. Kerb weight with the petrol engine is approximately 2,910 lb., which is 560 lb. less than the Champ.

The Gipsy impresses one immediately as a rugged practical vehicle on which a serious effort has been made to reduce routine maintenance work. The suspension system requires no lubrication and the use of nylon-encased steering ball pivots eliminates the need for grease at these points. The taxi engines, petrol and Diesel, are obviously well-proved units designed for long hard service.

Some boldness has been shown in simplifying the independent suspension to the point where it uses only four simple trailing arms. These are deep fabricated members made from steel pressings, those at the front being pierced to allow the track rod to pass



The "Gipsy" reaches the last stages of production. Components and sub-assemblies are brought to the main line by overhead conveyors. On the right is a detail of the suspension. Single trailing arms are pivoted on torsional rubber mounts. Steel springs are entirely eliminated.

through. Obviously wheelbase and caster angle vary with suspension deflection, and with the parallel wheel action unrestrained by any anti-roll device one might expect excessive roll on corners coupled with an exaggerated tendency to nose dive when braking. In fact none of these defects is apparent either across country or on hard roads. Suspension rates have been chosen so as to give adequate control with a remarkably comfortable ride over rough country. Practically no roll is apparent even when cornering quickly on hard roads, and nose diving under hard braking is no more than on more conventional vehicles. The car tested showed a tendency to pull to the right when braking which might have been a question of adjustment only. It was found, however, that loss of braking efficiency through entry of water persisted for some distance.

Controllability over rough ground was excellent; the occupants experienced very little shock, and practically no reactions were felt through the steering wheel. On the road, however, the steering seemed indefinite on the straight and showed an excessive degree of understeer on sharp corners. It hardly seems that this can be due to any excessive deflection of the trailing arms carrying the wheels in the rubber suspension units, in view of the figures for angular deflection quoted below.

—	Front	Rear
Approx. periodicity ..	115 c.p.m.	125 c.p.m.
Axial stiffness ..	18,000 lb.-in.	22,000 lb.-in.
Radial stiffness ..	140,000 lb.-in.	156,000 lb.-in.
Resistance to tilting ..	40,000 lb.-in./deg.	56,000 lb.-in./deg.
Tilt (normal loading)	½ deg.	¼ deg.

Total deflection range at wheel 6½ in. approx., of which 3 in. is static deflection.

During the development period the car was tried without any suspension dampers at all, but it was found that some degree of external damping was needed to supplement the self-damping characteristics of the rubber suspension. Telescopic dampers were therefore added at the rear and piston-type dampers at the front, but the duty is so light that they have an abnormally long life. Austin's say one of the Gipsy prototypes has covered 2,200 miles on the punishing pavé section at the M.I.R.A. proving ground without failure of any suspension element, an achievement possibly without parallel.

MOTOR EXPORT RECORD

In 1957 the British motor industry built 1,150,818 vehicles, which represented an increase of more than 150,000 units over the preceding year. This increase is due entirely to the progress made by the automobile manufacturers (860,842 units against 707,594 in 1956) because the production of commercial vehicles was slightly reduced (289,976 against 298,609).

But it was in exports that the greatest progress was made, all previous records being beaten. 549,555 vehicles were exported of which 426,272 were cars and 123,283 were commercial vehicles. To these figures must be added 114,965 tractors.

The United States were by far the most important market for British cars, having taken 94,867 against 38,205 in 1956. Australia is still in second position despite a decrease due to Government restrictions (49,056 against 55,878 in 1956). But the value of Australian imports was less than the value of the 42,000 cars exported to South Africa (an increase from 22,519 in 1956). New Zealand in fourth place took 32,900 cars, Canada 28,872, Sweden 20,269 and Belgium 17,611.

Australia is still numerically the most important British market for commercial vehicles despite a fall last year (15,908 against 17,298), but here too the value of the imports was less than the figure of 13,171 vehicles sent to South Africa. British West Africa was third with 7,162, and Argentina fourth with 4,847.

Australia was also the most important market for British tractors, taking 20,302, South Africa took 9,647 and New Zealand 9,117. It is interesting to note that France, in seventh place, took 4,853 and Germany took 3,788.

It would be interesting to analyse the relative progress of the different makes to know what kinds of cars are most in demand, but unfortunately the Society of British Motor Manufacturers and Traders, alone of the organisations representing the big vehicle manufacturing countries of the free world, refuses to release information on this subject.

FRENCH CARS TAKE THIRD PLACE

France is third among Europe's motor-car manufacturers and the fourth biggest producer in the world. In the general pattern of French industry, motor cars set the pace. Over a million men are directly or indirectly concerned in the industry, according to figures provided by the Chambre Syndicale des Constructeurs d'Automobiles. The Renault plants alone have 58,000 workers. The industry has a great appetite for raw materials. It consumes 1½ million tons of steel products, 25,000 tons of aluminium, 20,000 tons of copper and its alloys, 25,000 tons of paint and solvents and 2 million square metres of glass. Last year French manufacturers made up on the export market for home losses caused by increased prices, higher insurance rates, tighter credit and dearer petrol. During the year French factories turned out some 928,000 motor vehicles, 724,000 cars and 204,000 lorries. This was an increase of 12 per cent. on the figures for 1956, 649,000 cars and 179,000 lorries.

Exports increased at a greater rate than production to a total of over a quarter of a million vehicles, including 219,000 cars. This increase is at the very impressive rate of 43 per cent. over the previous year. For cars the increase is even better, 47 per cent. compared with only 18 per cent. for lorries. Renault alone sold nearly 31,000 vehicles in the United States, an increase of 885 per cent. on 1956. The Renault Dauphine was second only to Volkswagen among imported light cars. The forecasts are that this year 60,000 French cars will cross the Atlantic. All told, France exported 27 per cent. of the vehicles it produced last year. For the other big producers the figures were: Britain 47·5 per cent. exported, Germany 48 per cent., Italy 34 per cent., and the United States 6 per cent.

CARS IN SWITZERLAND

Over 94,000 new motor vehicles were licensed in Switzerland during the twelve months ending September 30, 1957. These new additions brought the national total up to 668,000 or some 10 per cent. more than in the year before. This means that there is a motor vehicle of some sort for every eight Swiss citizens, one motor car for every fifteen, one motor cycle, motor scooter or motorised bicycle for every twenty persons. The grand total is expected to pass the 700,000 mark during the coming summer. Of the new additions it is interesting that the biggest increase in demand was for low horsepower cars. Sales of motor cycles and motor scooters fell during the year.

General Motors Suisse at Bienne is now turning more and more to the assembly of the smaller Opel and Vauxhall models. The demand for big American cars has increased by less than 1 per cent. Imports of cars from West Germany, however, have gone up by 12 per cent., representing some 38,000 vehicles. Next comes France with an increase of 6,900 vehicles or 14 per cent. Bringing up the rear are Italy with a 9 per cent. increase and Britain with 5 per cent.

VAUXHALL VICTOR ESTATE CAR

Making its debut at the Danish Motor Show at Copenhagen is a new estate car, latest addition to the Vauxhall Victor range. Based on the Victor Super, with similar trim and equipment, it is a four-door model with single-piece lift-up tailgate. Rear seats can be folded away to give a cargo platform 5 ft. long behind the driving seat, and up to 45½ cub. ft. of cargo space. Maximum floor width is 4 ft. The tailgate, counterbalanced by strong torsion-bar springs, swings up to give ample headroom during loading and unloading. The spare wheel is carried vertically in a recess at the side.

All-round vision is a feature, with curved rear quarter windows and very slim rear pillars. Compared with the saloon, rear axle load capacity has been increased by using heavier gauge axle tubes, larger hub gearings and heavier rear springs. Rear axle ratio is 4·625 : 1 against 4·125 for the saloon, and rear springs have 5 leaves instead of 3, giving a rate of 124 lb.-in. against 100 lb.-in. Tyres are also larger, 5·90-13 against 5·60 and have six-ply covers instead of four-ply. Kerb weight is 2,320 lb. (1,055 kg.), an increase of 165 lb. (67 kg.) over the Super saloon. Dimensions overall are the same except for a half-inch increase in height. Like the saloon, the estate car is of all-steel unit construction.

Two-pedal control, now available on all Victor models, uses a centrifugal clutch of Newton design with a carefully studied control system. A compact control unit operating through the throttle linkage is mounted on the dash panel to isolate it from engine vibration. It governs clutch action through solenoid valves, controlling the vacuum cylinder which withdraws and re-engages the clutch. The clutch is automatically disengaged when the gear lever is touched there being electrical contacts in the knob.

The centrifugal clutch automatically takes up the drive as the accelerator is depressed and disengages it when engine revolutions drop below 900 r.p.m. The engine cannot be started unless the gear lever is in neutral. To prevent the clutch engaging while the engine is idling fast during warming up, a choke control inhibitor switch is fitted, bringing into operation a vacuum bleed which delays clutch engagement until the accelerator is depressed.

Another refinement is provision for parking in gear. This is done by a pull-out control on the instrument panel which puts the centrifugal control mechanism out of action, giving a solid connection between engine and rear wheels. Automatic clutch operation is restored when the engine is started.

Companies in the News

Amber Light for Recovery

Some weeks ago we pointed out in these columns that a few sparks of recovery were to be seen in the machine-tool market. Two recent statements on prospects—by Asquith Machine Tool Corporation and the Coventry Gauge and Tool Company—generally confirm this. The board of Asquith make a most confident forecast of the results for the current financial year, of which nearly five months have elapsed. The profit distribution for the present year is being increased, an indication that the management are not unduly perturbed about the slowing down of new orders now being experienced by the industry. The statement clearly suggests that the board are well satisfied with the order intake as well as with the current production rate.

Coventry Gauge and Tool are, by nature of their business, extremely sensitive to trade fluctuations. Their chairman, Sir Stanley J. Harley, points out in his report that orders are more difficult to get and that customers tend to defer decisions on outstanding business. Nonetheless he has enough confidence in the future to tell his shareholders that " we need not be unduly pessimistic." Both Coventry Gauge and Tool and Asquith have a wide range of activities. In the case of Coventry Gauge and Tool it has a very wide spread in products of both a capital and revenue nature. In the case of Asquith, they have expanded and broadened their structure and have shown themselves capable of making appropriate adjustments to meet changes in the pattern of demand.

The index of machine-tool demand is a very sensitive barometer of industrial activity. Nothing is quite as easy to defer as the decision to replace a machine or to build a new factory. About three months ago there was a tendency on the part of many engineering firms to consider placing the orders they had deferred. This was due to a feeling that " things were better " on the whole. Suez was past, the home market more active, exports high. Now there may be a fall in exports though a rise in commodity prices (perhaps also at the point of turn) would quickly set this aright. Next year may, after all, be a good one for British engineering.

Contractors' Difficulties

British contractors are beginning to feel the twin draughts of Government restrictions on investment at home and falling commodity prices abroad. The annual report of J. Alfred Pratt and Company (1928) Limited, the roofing contractors who also merchant building materials, contains a warning that the immediate future of the industry " cannot be viewed without some misgiving." They, and the rest of the industry, are particularly hard hit by the fall in house building due to credit restrictions and high interest rates. Their chairman and managing director, Mr. Charles F. Golton, points out that the building industry is " always slow to revive after it has been restricted," and hopes that the Government will take care that activity does not fall too low. The decision not to cut work on roads and hospitals is welcomed, but the cuts in school building have left an important gap. Increasingly, therefore, activity will be hard to maintain at a profitable level.

Overseas construction companies operating in primary producing areas, where most of their " export " business lies, are finding signs that work is likely to fall because those countries are earning less through their exports of raw materials and foodstuffs. So far the work available has not been greatly affected, but the value of work outstanding has tended to decline. The value of contracts obtained in 1957/58 is unlikely to be very different from the £92 million of the previous year, but 1958/59 is expected to show a marked fall. Competition from American, German, Italian and other foreign construction companies is becoming intense and margins have tended to fall. Moreover, Soviet bloc countries are becoming more active in the Near East and in Asia.

One of the adverse factors in competing for overseas business is the high cost of finance in the United Kingdom. This makes it difficult to compete on equal terms with foreign companies, and British firms have become more cautious about extending their overseas commitments. For the dozen companies or so who have current contracts abroad exceeding £1 million (half of them have £5 million or more) this continued effect of high home interest rates and falling commodity prices is most serious.

Progress by Power-Gas

A very satisfactory rate of growth is being maintained by the Power-Gas Corporation Limited, who describe themselves as " gas, chemical, petroleum and blast-furnace plant engineers." The group's gross trading profits for the year ended September 30 amounted to just over £1 million, compared with £860,000 the previous year, and their order situation was very satisfactory. In his statement to shareholders the group's chairman, Mr. W. R. Brown, pointed out that a fat order book should not be interpreted as a passport to easy living during the next few years. He gave details of various steps the group were taking to make themselves more competitive, by plant modernisation and by paying close attention to the building of first-class technical teams, and warned that " there is no room for complacency, even though our long-term contracts ensure a high measure of employment for some period ahead."

The group have been very active in their search for new contracts, to maintain what Mr. Brown called " profitable and uninterrupted continuity of operations." Continuity is of the greatest importance in this type of heavy engineering where contracts tend to be large, and are therefore hard to fit into a smooth sequence. The shop must be loaded a long way ahead if waste is to be eliminated. In the year under review, orders booked amounted to £12·3 million, which approximates to the record level achieved in 1956. Mr. Brown pointed out that it would be " foolhardy " to ignore clear indications that some schemes are likely to be postponed until the Government's restrictive measures are eased.

Reviewing the group's activities, Mr. Brown announced that a new petroleum plant division had been established as a " natural sequel " to the business already established with that industry. The orders booked by the blast furnace division (trading as Ashmore, Benson, Pease and Company) were the highest ever and included five major contracts. The gas industry's interest in the gasification of oil has led to substantial orders for Segas plants. But, the chairman points out, changes in the technique of gas making have involved the group " in considerable expenditure on research and on the acquisition of operating experience and data." In this manner Power-Gas have gone ahead and appear to have excellent prospects in a difficult period.

New Wagon Group

Two famous companies of railway carriage and wagon builders may soon come together in a new group. Shareholders of Hurst Nelson and Company have been told of an offer by Charles Roberts and Company to purchase the whole of the ordinary capital of their company for about £740,000. The proposed settlement is on the basis of an allotment of four ordinary shares of Charles Roberts and Company for each £1 ordinary of the 400,000 £1 shares of Hurst Nelson and Company plus 5*s*. per share in cash. Acceptance of the offer is recommended by the board of Hurst Nelson and Company.

The building of railway wagons has gone on at an increasing rate ever since the modernisation of British Railways was begun in 1955, and most of the companies in the industry have enjoyed full order books and a high level of activity. There is no sign that this is coming to an end; on the contrary, the wagon building shops of the whole industry are likely to be kept at full stretch for the whole of this year and most of next. This was confirmed in the annual report of the Central Wagon Company, who are perhaps best known as wagon repairers, but also build new stock. Apart from substantial orders for new wagons, they have a contract worth some £1½ million for vacuum-brake conversion of 10,000 16 ton mineral wagons.

The merger of Charles Roberts and Hurst Nelson will substantially increase their chances of competing for overseas business on equal terms with other British firms and with foreign builders who have gained ground at the British industry's expense in recent years. In 1957 carriage and wagon exports amounted to about £7 million compared with £7½ million in 1956. The need for an extensive overseas sales organisation is becoming more pressing and can be catered for much more easily by large units. The new group should therefore improve their export position as soon as they have been able to integrate their present facilities. For some time in the near future, however, the home market will be by far the most important, both for coaches and wagons. Output of the latter rose from 51,000 in 1953 to 70,500 in 1956, and was higher still in 1957. The percentage exported has tended to decline. In 1953 18 per cent. of the total number of wagons produced were to overseas markets; in 1955 this had fallen to less than 5½ per cent. but had recovered to over 9 per cent. in 1956. The Charles Roberts—Hurst Nelson group should be able to cash in on this recovery.

Uphill Climb

The annual statement of the chairman of Associated Motor Cycles Limited, Mr. S. R. Hogg, made quite clear that the making of profits out of motor cycle manufacture is not easy. The first half of the financial year ended at August 31 was disastrous for the whole industry. The Government's introduction of hire-purchase restrictions requiring a minimum deposit of 50 per cent. caused a fall in output of nearly 30 per cent., and there was no recovery until the legal minimum deposit was reduced to 20 per cent. towards the end of 1956. The improvement which followed was so substantial that the industry's output during the second half of the financial year (March to August) was 50 per cent. higher than in the same months of the preceding year.

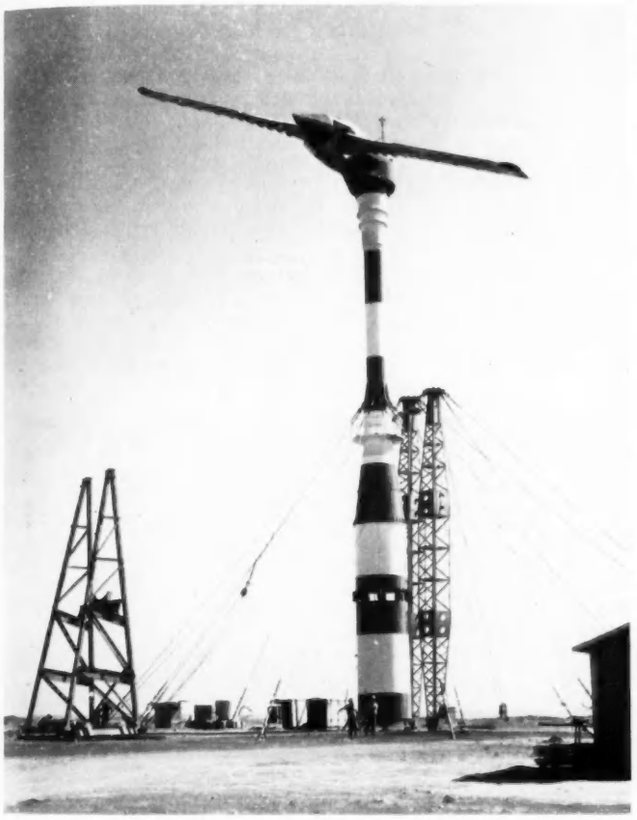
Associated Motor Cycles increased trading profits by some £100,000 to £327,000. All of this increase was not attributable to the recovery in sales. Much of it was due to reductions in the stock in hand, and to the strenuous efforts which were made to reduce costs. Commenting on the Government's decision last May to raise the minimum cash deposit on hire-purchase transactions to 33⅓ per cent., Mr. Hogg said " I cannot stress too forcibly the harm that frequent changes of this type cause, since they make it impossible for a manufacturer to plan his forward production." Many manufacturers of products which sell extensively on a hire purchase basis will back his plea for stability and share his view that the minimum requirement should not exceed 25 per cent. On the other hand, the manipulation of legal minima for hire-purchase cash deposits are one of the most effective means the Government have for controlling inflationary home demand, and they are unlikely to abandon it easily.

Mr. Hogg expressed his confidence that the motor cycle industry " now on the upward grade from the last two years of recession," would recover its buoyancy and prosperity.

Special Article

WIND POWER: BRITISH MACHINE IN ALGERIA

Many people have asked for news of the 100 kW Enfield-Andreau experimental wind-driven generating plant which was ordered from Enfield Cables Limited, Victoria House, Southampton-row, London, W.C.1, by the British Electricity Authority in 1950. Readers of ENGINEERING may have noticed that, in the September 14, 1956, issue, a Weekly Survey note recorded that the machine had been shipped to Algiers for testing by the Service des Études Générales et Recherches, Electricité et Gaz d'Algérie. Since then, although the machine has been featured in the Algerian Press and radio, and has been the subject of an article in the UNESCO *Courier*, no information about it has been published in the United Kingdom—mainly because, until some three months ago, there were no concrete developments to report. It took a long time to acquire and prepare the site at the top of " Grand Vent Deux " where the machine now stands, and it was not until November, 1957, that testing commenced. The results were startling in their success. Within the first seconds of operation, the output rose to 130 kW (30 per cent. above rated output) and for the 20 following minutes never fell below the rated figure.



The 100 kW Enfield-Andreau alternator, originally commissioned by the British Electricity Authority, is now installed on a site in Algeria. On its initial run there it achieved an output of 130 kW.

Three British companies who had acted as sub-contractors to Enfield Cables Limited were represented at the first trials in Algeria: de Havilland Propellers Limited, Hatfield, designers and makers of the propeller head and blades and the turbine, who were responsible for the dismantling, transportation and final re-erection of the machine at its present site jointly with the Redheugh Iron and Steel Company (1936) Limited, Gateshead, who were responsible for the structural steelwork; and the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, who designed and constructed the electrical equipment.

The successful application in the United Kingdom of nuclear energy to the generation of electricity has somewhat diverted official British interest from the possibilities of wind power as an alternative source of electrical power. In other parts of the world, however, the potentialities of wind power are being further explored. Algeria is one such area: here, seasonal variations of wind energy and rainfall tend to be complementary, so that wind power, if used to supplement an existing hydro-electric scheme, could appreciably reduce the risk of a serious dearth of energy, and of reservoir sedimentation, during very dry years.

For these reasons, the United Kingdom Central Electricity Authority offered to Algeria the opportunity to re-erect, in Algeria, the Enfield-Andreau wind-driven alternator—a heartening instance of international co-operation, and generosity on the part of the British official organisation. Under the auspices of the Service des Études Générales et Recherches, Electricité et Gaz d'Algérie, the machine will there undergo a five-year development programme on a " semi-industrial scale."

The Enfield-Andreau alternator, it may be recalled, was described in the March 25, 1955, issue of ENGINEERING shortly after it had been installed at Prae Wood, St. Albans. Briefly, it operates on the depression principle developed in France by the late M. Andreau: the blades of the wind-driven variable-pitch propeller are hollow, and as they rotate air is discharged through tip outlets by centrifugal force. The depression thus generated causes air to be drawn up into the blades, through an air turbine, near the base of the tower which drives the alternator. Thus, there is no mechanical connection between alternator and propeller. The latter operates at a constant speed of 100 r.p.m. at wind speeds above 30 m.p.h., giving a constant volume of air flowing through the turbine (58,500 cub. ft. per minute). The electrical output is held constant at 100 kW between wind speeds of 30 and 65 m.p.h. Below wind speeds of 30 m.p.h., the propeller operates at constant pitch and the output of the turbine falls rapidly as speed decreases.

The installation at St. Albans was carried out

Continuing Wind Power

primarily as an erection drill and it had never been envisaged as a suitable site for assessing the performance; and subsequent running experience at St. Albans demonstrated that wind conditions at the site were completely inadequate. In all, some 60 hours of running was completed at Prae Wood over a period of about two years; and the maximum power developed was 25 kW at 98 propeller r.p.m., with a measured depression of 16½ in. of water. In the original installation, there was a free-wheel arrangement between the air turbine and the alternator; the turbine ran free until a speed of 1,000 r.p.m. was attained when it latched on to the alternator shaft. When the machine was re-erected in Algeria, the free wheel was eliminated, the turbine rotor being coupled solidly to the alternator, which assists in stabilising the alternator at synchronous speed during starting when the alternator is motoring.

The hill site on which the Enfield-Andreau generator has been erected in Algeria, known as Grand Vent Deux, was selected from a number of sites investigated by the Service des Études Générales et Recherches over several years. It is about 7 miles from Algiers and 850 ft. above sea level. Being some 5 miles from the coast, there is no risk of sea-water corrosion of the machinery. Other advantages of the site are its proximity to a 10 kV distribution line and to one of the main highways. Apart from the elimination of the free wheel as described above, and a minor re-arrangement of some of the control items, the wind-driven generator, as erected at Grand Vent Deux, is exactly as it was at St. Albans.

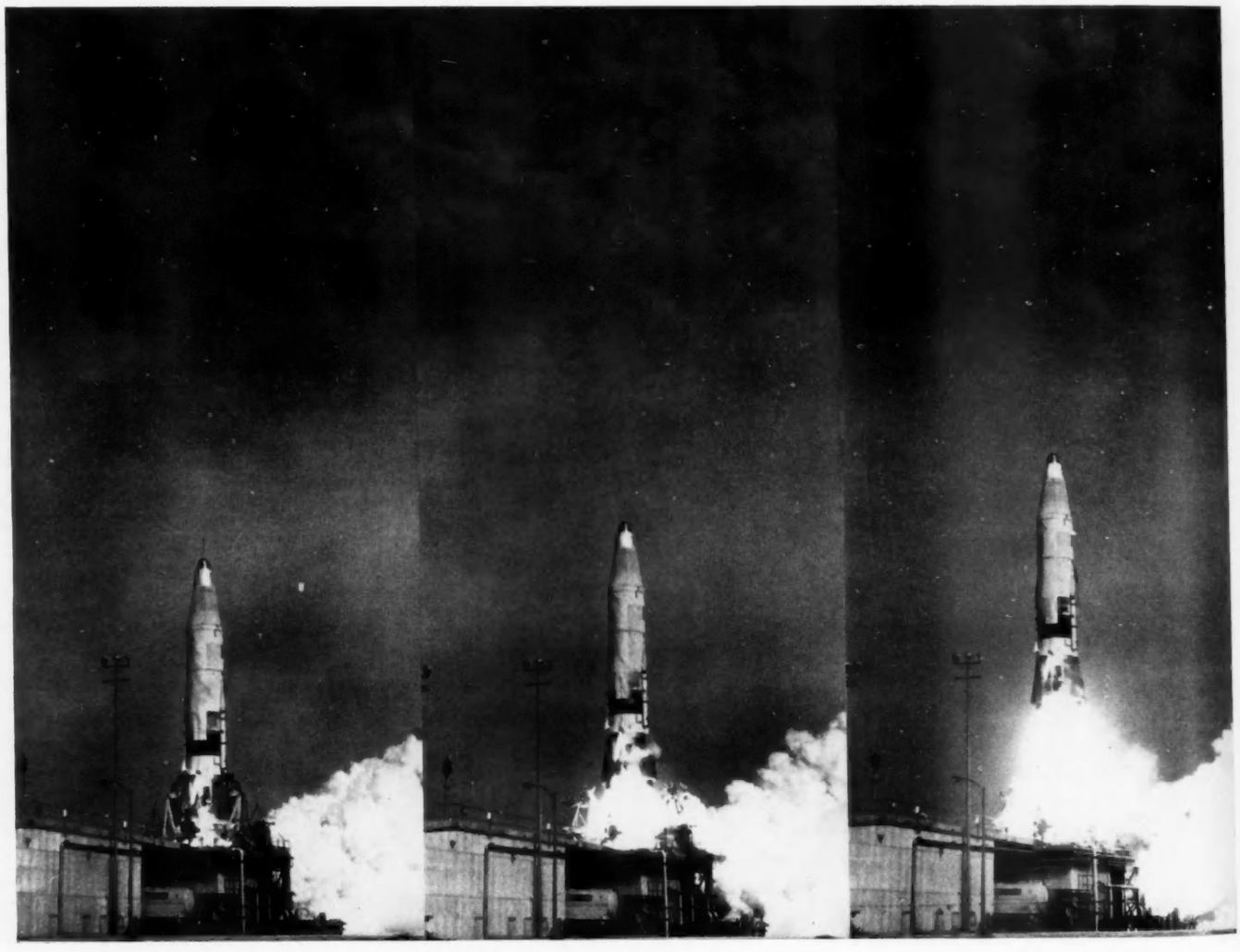
Re-erection was completed early in November, 1957, and the initial proving runs were carried out, with conspicuous success on November 9, as already recorded. The machine was then handed over to the Algerian authorities, and we understand from them that subsequent running has amply confirmed the initial satisfactory results. During the next five years, a development programme is to be carried out covering detailed performance measurements, and including vibration checks on the tower and the propellers to prove the design assumptions. During this period, de Havilland Propellers Limited will contribute any technical advice necessary to bring these tests to a final and satisfactory conclusion.

FROM THE GROUND UP

Launching the Atlas Intercontinental Ballistic Missile

Missiles, like players on a stage, have their exists and their entrances, both take-off and re-entry being critical phases in their flight. Re-entry into the earth's atmosphere is a problem that has yet to be satisfactorily solved, but already a number of ballistic vehicles have been launched successfully in the United States and elsewhere. Atlas, the first intercontinental ballistic missile to be built in a Western country, is in pilot production at the Convair-Astronautics plant in San Diego, California, and has been flight tested on several occasions. Intercontinental ballistic missiles are long-range surface-to-surface vehicles, such as Atlas, in which the flight path is a trajectory. The illustrations on this and the facing page show the missile on its launching pad and during launching. Convair is a division of the General Dynamics Corporation, San Diego 12, California, U.S.A.

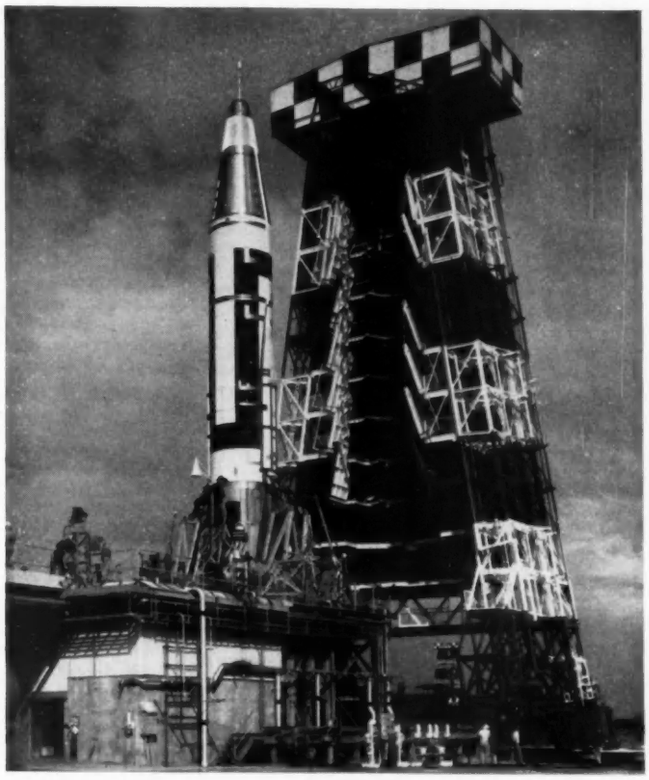
In the top picture on the next page, Atlas is shown on its launching pad, standing clear of the gantry tower, at the Air Force Missile Testing Centre, Cape Canaveral, Florida. The gantry tower, which is used in preparing the vehicle for flight, is being moved away from the launching area. Working platforms installed at regular intervals in the centre of the

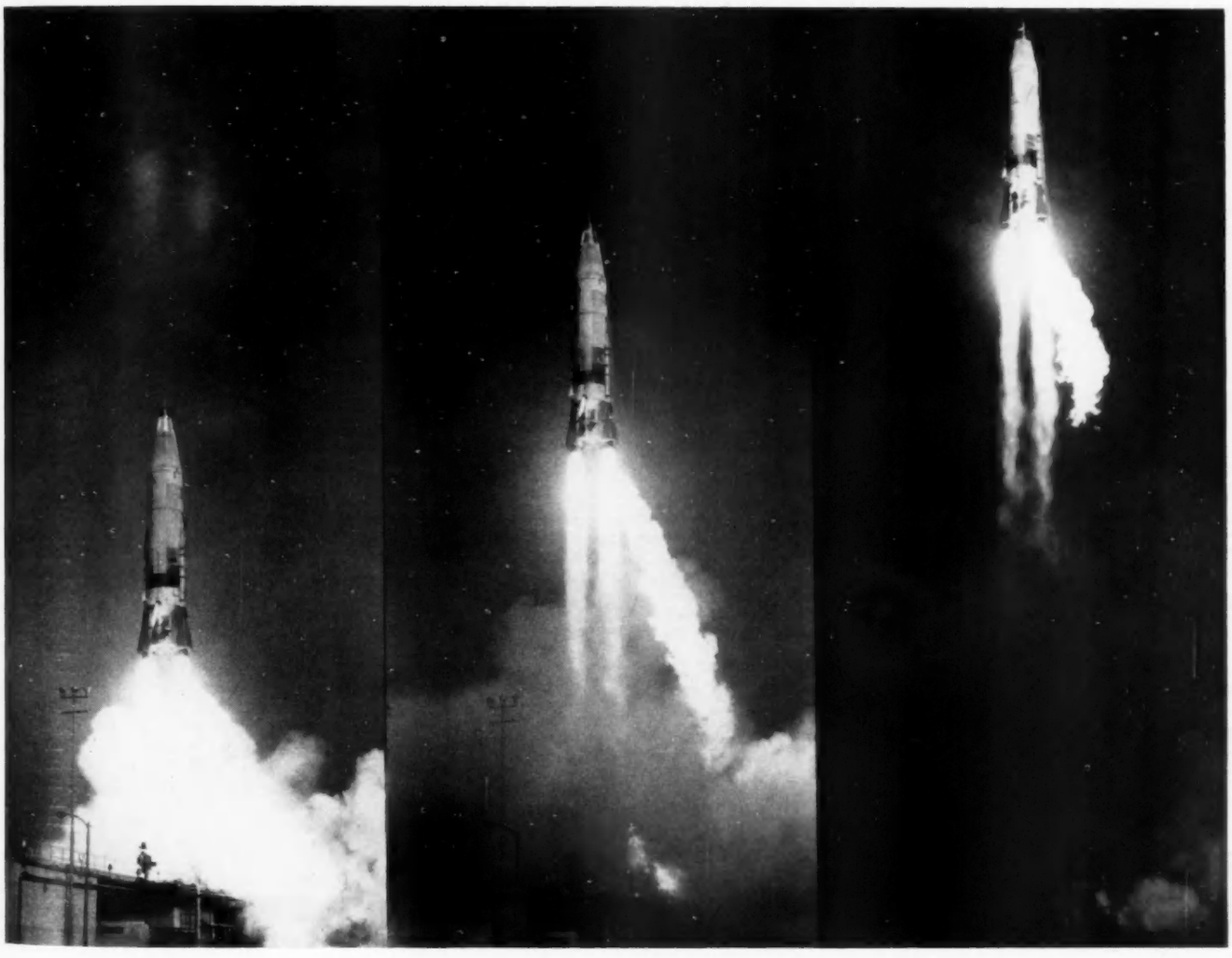


tower are folded upward before the gantry is withdrawn. Launching arms can be seen clutching the missile near its base to stabilise and secure it during final fuelling and engine ignition. In the background between the legs of the tower a second Atlas gantry is visible.

The sequence of views at the foot of this and the preceding page are high-speed camera records of the Atlas missile rising from its launching pad. On the left the engines are shown being fired as the missile, its surface coated in frost from liquid oxygen, is poised for take-off held by the launching arms. In the second picture the arms spring away and Atlas begins to rise, and in the third flames bathe the launching mechanism as the missile gathers speed. In the first picture on this page twin incandescent jets from the rocket engines become visible as the missile climbs clear of its wake of flame and steam. In the last two pictures expendable launcher tubing can be seen burning on the pad as the missile rises to begin its journey; the plume of flame spurting from the missile base at the right is exhaust from the fuel-system turbo-pumps. The launching took place on January 10, this year.

Designed and built by Convair, the Atlas, designated SM-65, has a skin so thin that, to preserve the shape of the body as the propellents are consumed, the interior (comprising integral tanks) has to be pressurised. This construction gives a high fuel-to-structure mass ratio. Various figures have been reported for the thrust of the power units. According to *Flight*, the integral tanks contain fuel and liquid oxygen, which are fed by turbo-pump to a single gimbal-mounted chamber, rated at 65,000 lb. thrust and mounted towards the base of the missile. On each side of this motor a further single-chamber motor is pivoted, giving 135,000 lb. thrust, designed to boost initial propulsion. The two booster motors burn for 180 seconds and are then jettisoned together with the flared skirt, incorporated to provide added directional stability. All three motors are fired on the ground, though in the illustrations it would appear that only the two outer motors are operating. The principal contractor for the propulsion equipment is the Rocketdyne Division of North American Aviation, and the American General Electric Company is mainly responsible for the guidance system.





In Parliament

AIRCRAFT NOISE

That vexed question, how to reduce aircraft noise, came before the House of Commons last week, when Mr. Anthony Kershaw (Conservative) pressed for action to be taken in connection with the disturbance caused by aircraft flying over the parish of Kemble.

He was told by Mr. Charles Orr-Ewing, the Under-Secretary of State for Air, that most of the flying from Kemble was done by aircraft from the Central Flying School at Little Rissington. As a result of strong representations, the programme and pattern of flying had been changed to reduce as far as could be done the inevitable disturbance. Last year night flying at Kemble had continued after midnight on only nine occasions. Whenever possible, aircraft using the main runway took off to the west and headed away from Kemble village.

The Minister said that he had himself recently visited the Central Flying School to see if there were anything further that could be done and the Air Ministry would continue to watch the problem closely, but he was afraid that it could not suspend flying training.

IRON AND STEEL COSTS

Asked by Mr. John Cronin (Labour) about basic costs in the iron and steel industry, Sir Ian Horobin, the Parliamentary Secretary to the Ministry of Power, said that the approximate average hourly cost of labour in 1957 was 5*s*. 9*d*. The approximate average costs of coking coal and scrap metal, including imported scrap, delivered to steelworks during the same year were £5 a ton and £13 a ton, respectively. Invited by Mr. Cronin to agree that these figures were lower, in general, than those of any other major steel-producing country and that, therefore, the present efficiency of the industry was largely due to factors outside the control of the various boards of directors, Sir Ian retorted that he could accept neither Mr. Cronin's premise nor his conclusion: there was, in fact, every kind of statistical trap in figures of that kind.

Sir Ian told Mr. A. M. F. Palmer (Labour/Co-operative) that about five-sixths of the country's iron and steel productive capacity had been returned to private ownership, and that about one-sixth remained in the control of the Iron and Steel Holding and Realisation Agency. The Iron and Steel Board, he emphasised, superintended the whole of the industry, as defined in the third schedule to the Iron and Steel Act, 1953.

EMPLOYMENT TENDENCIES

Another problem that has been much under parliamentary scrutiny lately and which came before the Commons again last week, in the form of both questions and debate, was the existing level of employment. The debate was opened by Mr. James Griffiths, Labour member for Llanelly, a former Minister of National Insurance and at one time President of the South Wales Miners' Federation, who moved "That this House expresses its concern at recent increases in local unemployment and calls upon the Government to take appropriate action to remedy the situation."

He first referred to unemployment in the shipping industry and then said that, throughout the period of full employment, there had been certain areas that invariably had had a percentage of unemployment above the average. When unemployment spread, these areas felt the first draught. A fairly large proportion of industry established in development areas consisted of branch factories. When a general recession began, these areas were among the first to be affected, because companies compelled to cut down production cut down on the fringes. An example of this course was provided by the Birmingham Small Arms Company, Limited, which, he was informed, had announced that its tools factory at Cardiff would close permanently at the end of February. The work which had previously been performed at Cardiff would be concentrated in future at the firm's major plant in the Midlands.

It might be that, even with the best will and best efforts in the world, some men were fated to meet with long-term unemployment. To deal with such cases, he urged that the Government should restore Section 62 of the 1946 National Insurance Act. By that Section, provision was made for payments to such men to be a charge on the Exchequer and not on the National Insurance Fund, and they would be spared the indignity of going to the National Assistance Board.

EFFECT OF GOVERNMENT POLICIES

On behalf of the Government, Mr. Iain Macleod, the Minister of Labour and National Service, moved an amendment so as to make the motion read "That this House, while recognising the concern felt at recent increases in local unemployment, welcomes the intention of the Government to continue the practical steps being taken to deal with pockets of unemployment in particular localities."

It was idle to deny, he said, that, although most of the increase in unemployment had arisen from seasonal causes, some of it had come from Government policies. The Government believed those policies to be right. Again, he did not believe it to be possible to avoid some situations of local difficulty in a changing economy. The February figures showed that unemployment had increased by 28,000. This meant that the percentage of unemployed had risen to 1·9 of the number of persons in work, but this increase appeared to be a real and not a seasonal increase.

The position in certain areas in Wales was not as bleak as the figures, by themselves, would suggest. New projects were coming forward and they would provide for substantial temporary construction work and, thereafter, for a permanent labour force. It was of the first importance to consider remedies in the light of the defence situation, which, in 1957, had caused probably the most drastic changes in the employment position since demobilisation. While, during the twelve months ended November 30, 1957, the numbers employed on defence production declined by nearly 150,000, unemployment in the whole of the manufacturing industries, of which defence was only a part, increased by only 15,000.

In a modern economy there was bound to be a change and a good deal of mobility of labour. Both the Government and industry could help. There was a better chance of achieving price stability now than at any time since the war. A number of other members took part in the debate, and the motion, as amended, was later carried by a Government majority of 51.

COMPULSORY RADAR TRAINING

Regulations have been imposed by the Governments of Australia, New Zealand, India and the Irish Republic, similar to those in force in the United Kingdom, providing that no new certificate of competency as a foreign-going second mate shall be issued unless the candidate also holds a radar observer's certificate, according to an answer given by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation. Other Commonwealth Governments were understood to have this matter under active consideration, but no foreign Governments, he told Mr. J. V. Woollam (Conservative), had yet introduced comparative requirements.

The Minister was asked whether his attention had been drawn to the 1957 annual report of the Liverpool Underwriters' Association urging that early agreement should be reached between maritime nations to make radar training a compulsory requirement for ships' officers. Mr. Watkinson said that he had already notified Commonwealth nations of the provisions laid down in the United Kingdom. A number of them had responded and he was now drawing the attention of other maritime countries to Britain's action. He hoped that that would lead to a greater appreciation of the need for such regulations.

SATURDAY WORK IN THE MINES

A plea for the elimination of Saturday working in British coal-mines was put forward by Sir William Robson-Brown (Conservative). He stressed the position that the working of a five-day week would have a marked effect on costly day-to-day absenteeism and that it would yield an all-round improvement in operating costs, combined with advantages to the miners. Mr. Reginald Maudling, the Paymaster-General, replied that Saturday working was the subject of an agreement between the National Coal Board and the National Union of Mineworkers which was renewed annually in April. He had no doubt that the full economic considerations, including those referred to, would be borne in mind when the agreement next came up for renewal.

Purchases of Comet II Aircraft

Answering a point raised by Mr. Frank Beswick (Labour/Co-operative) regarding the purchase of three incomplete Comet II aircraft, Mr. W. J. Taylor, Parliamentary Secretary to the Ministry of Supply, said that these three aircraft were purchased in 1955 as a reserve at the same time that 13 other Comet II's were bought for the Air Ministry. The need to use the aeroplanes had not materialised and it would cost money to preserve them. The decision had been taken to scrap them and their purchase price of £500,000 was being transferred from the Ministry of Supply's purchasing (repayment) services vote to the main vote, in order that the original payment might be accounted for.

Fumes from Diesel Oil

Mr. Derek Walker-Smith, the Minister of Health, informed the House that investigations conducted by the Medical Research Council on groups of persons especially exposed to fumes from Diesel engines had demonstrated no immediate or long-term effects on health. Sampling of the atmosphere, he told Mr. Richard Hornby (Conservative), showed that Diesel fumes contributed little to the total atmospheric pollution. These studies were continuing, however, together with research into the nature of Diesel exhaust fumes under different running conditions, both experimentally and in the field.

Poole Ordnance Factory

Owing to reductions in orders, it would not be possible to keep the Royal Ordnance Factory at Poole in operation until the financial year 1959-60, as was previously envisaged, Mr. Taylor told Captain R. A. Pilkington (Conservative). Established employees would have the right to be transferred to other Government establishments and every effort would be made, in collaboration with the Ministry of Labour, to secure employment for other persons rendered redundant. A number of inquiries had been received regarding the purchase of the factory.

Inland Waterways Report

It was suggested by Mr. W. R. Williams (Labour) that there should be an interim report by the Bowes Committee regarding its inquiries into conditions on inland waterways, inasmuch as many disused canals were not only a hazard to life and health but were handicapping the housing and development authorities. In reply, Mr. G. R. H. Nugent, Joint Parliamentary Secretary to the Ministry of Transport, said that the drafting of the report was now in hand, but as the evidence had been voluminous and drawn from a wide field of interests, it would be some weeks before the report was complete. It would, however, be best to leave the committee to complete its final report. The committee members were aware that the report was wanted quickly.

Atomic Review

Lattice

THE framework within which reactor development proceeds has in recent months become more rigid. Limitations have been imposed, and the course of development is now more rigorously determined. Reactor systems which may take 20 years to develop have fallen from favour, since by then, other more economic methods of generating power may be available. Efforts are likely to be concentrated on the few promising reactors that are already at an advanced stage of practical application; among these are the gas-cooled and pressurised-water systems, which have by no means reached their limits. Engineering development rather than system study is the keynote of the next phase. Nevertheless, the situation has not yet fully hardened and there is still some scope for novelty. The reactor engineer is necessarily eclectic in his methods, and items conceived for more exotic systems may well find application in the advanced designs of basically conventional reactors. Even at this stage less familiar combinations of moderator and coolant may be adopted: thus the heavy-water moderated gas-cooled system is under consideration for ship propulsion. The following notes are devoted largely to matters relating to reactors.

Development of a Reactor System

The development of a reactor occurs in several stages and an indication of the time required for each has been given in an article, "Some Applications of Nuclear Power," published in the *de Havilland Gazette* (see Atomic Review last week). Advanced reactor concepts in particular, such as those necessary for aircraft propulsion, call for considerable research before they can pass from initial concept to commercial application. Fig. 1 gives an approximate time scale for this progression, and the following table lists some of the work involved in the case of a gas-cooled reactor.

Fig. 1 Time-table for the development of a typical reactor system, following the conception of the basic idea. The period for metallurgical research would also include physical and chemical studies. Construction of a commercial plant might follow the stages shown.

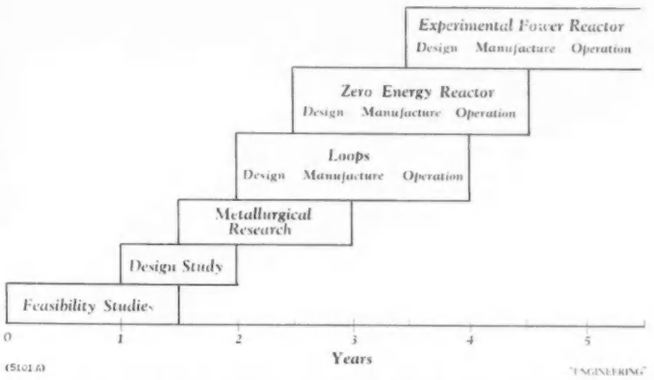


TABLE *Problems in the Development of a Gas-Cooled Reactor*

Nuclear Physics
Experiments on reactor materials
Zero-energy assemblies to determine optimum core configuration
Irradiation damage measurements on materials
Shielding problems—reduction of weight and cost
Health aspects associated with handling radioactive materials
Metallurgy
Mass transfer around coolant circuit
Development of new fuel elements
Corrosion and prevention of oxidation of reactor components
Development of new reactor materials
Engineering
Development of leak-tight circuits
Gas purifiers
Gas circulators
Heat exchangers
Fuel elements
Control systems

To ensure that design data are obtained in the shortest time with the minimum of effort, it is vital that the work of the various groups is phased so as to obtain as much overlapping as possible. At any one stage the proposed system may be rejected by the revelation of some new feature or information which makes the scheme unacceptable or necessitates a complete re-evaluation to determine whether further work is justified and, if so, which areas of research require most immediate attention. The probability of a system being rejected decreases as it advances successfully from one stage to another, but to offset this the effort expended on the project increases rapidly and a decision to abandon a project at a late stage of development necessarily involves a serious wastage of manpower and resources.

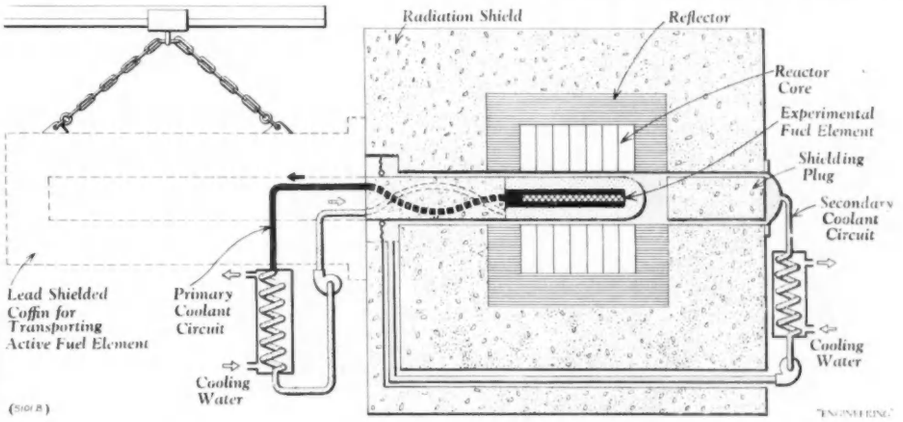


Fig. 2 (right) Arrangement of an experimental circuit or loop for testing a fuel element. The de Havilland Engine Company in collaboration with A.E.R.E. are testing a new kind of ceramic fuel element by means of loop experiments.

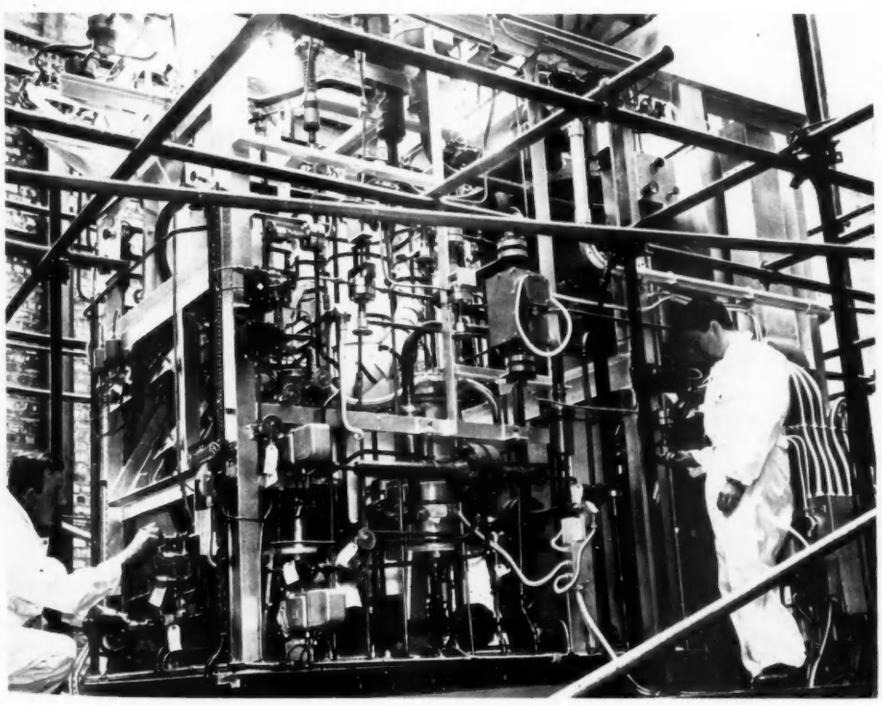


Fig. 3 (left) High-pressure water loop equipment built in the Renfrew research department of Babcock and Wilcox Limited. It has been designed for testing fuel elements under operating conditions in the DIDO materials testing reactor.

Loop Tests

If a particular reactor system appears attractive as the result of the preliminary design studies, then the next stage in its development is to carry out tests on all the vital reactor components under simulated operating conditions. In the case of the reactor development the preliminary engineering tests on components and circuits can be conveniently sub-divided into two categories referred to as "in-pile" and "out-of-pile." In the former case the experimental equipment is inserted in a research reactor so that the effect of nuclear radiations can be determined, whereas for the latter tests the more normal engineering techniques and facilities are adequate (for example the measurement of heat transfer and pressure-drop characteristics of new fuel-element designs).

A typical example of an in-pile engineering experiment is the closed-circuit or "loop" now being designed by the de Havilland Engine Company's Nuclear Power Group in collaboration with the Atomic Energy Research Establish-

Continuing Atomic Review

ment, Harwell, for testing a new type of ceramic fuel element. It is intended that this element should allow a significant increase in reactor operating temperatures (of the order of 800 deg. C.) and hence result in higher specific heat outputs and an improved thermal efficiency in the power-plant cycle. The element is inserted into one of the experimental holes of the research reactor and, when the latter is operating it is subjected to an intense bombardment by neutrons which escape from the core region of the reactor. The energy released as a result of fission in the uranium contained in the element appears in the form of heat. The temperature of the element can be maintained at any desired value by controlling the flow of cooling gas in the primary coolant circuit. The arrangement of a loop for testing a fuel element can be seen from Fig. 2, and Fig. 3 shows high-pressure water loop equipment built in the Renfrew research department of Babcock and Wilcox Limited. It has been designed for testing fuel elements in the DIDO materials testing reactor at Harwell.

Liquid-Metal-Fuel Reactor in Australia

Two reactor systems have been studied by the Australian Atomic Energy Commission during the past year: the high-temperature gas-cooled system (see Atomic Review, January 10) and the liquid-metal-fuel reactor system. In the LMFR, uranium 233-bismuth solution, or uranium 233-sodium slurry is circulated through channels in graphite or beryllium in the core of the reactor, while a thorium-bismuth slurry is circulated through the blanket, which is separate from the core, as indicated in Fig. 4. Thorium atoms in the outer thorium-bismuth blanket are convered into fissile uranium 233, while the heat generated in both the core and the blanket is withdrawn by circulation of the hot liquids through heat exchangers. There are three basic LMFR systems possible: (1) bismuth coolant and fuel carrier with graphite moderator; (2) bismuth coolant and fuel carrier with beryllium moderator; and (3) sodium coolant and fuel carrier with beryllium moderator. This type of reactor is mainly suitable for a base load station of 100 MW or higher. Cost studies have shown that if the considerable research problems can be solved, then it is basically capable of producing power at less than ½*d.* per killowatt-hour.

In this system the fuel is carried as a suspension or solution in the coolant and thus provides prospects of continuous chemical processing. There is a choice (subject to chemical compatibility under irradiation) of bismuth or sodium as coolant fuel carriers, and graphite or beryllium as moderator. The United States and United Kingdom are actively engaged on the bismuth-graphite system; Australia is devoting her attention to an initial study of the sodium-beryllium reactor.

General feasibility calculations have been undertaken, and critical sizes and fuel investments computed for a variety of moderator ratios and coolant fuel concentrations. Theoretical investigations have been made of the inherent stability of the reactor system, and these show that it should be possible to accept small changes in fuel concentration in the slurry. This problem is at present being experimentally studied at the Lucas Heights research establishment using as an analogue a slurry of tungsten powder in water. A sodium loop designed to pump 10 gallons per minute at 500 deg. C. is also under construction in a special building erected for the purpose. Pumps and valves had to be obtained from overseas, but the heat exchangers, tanks and loop have been fabricated in Sydney.

Some theoretical studies of possible heat exchangers for the reactors have been undertaken, and the result of these calculations has demonstrated the importance of the heat exchanger in determining the out-of-pile fuel investment and the necessity for some experimental work in this field. A sodium-uranium slurry has been successfully manufactured on a small scale. Equipment for further work on this problem is now being constructed at Lucas Heights. Investigations of the chemical compatibility of sodium with beryllium and with out-of-pile construction materials have begun. Mass transfer experiments will be set up at Lucas Heights as soon as laboratory facilities and equipment are available. Some preliminary studies of possible methods of chemical processing of the core have been made, but no laboratory work has yet been possible.

Abstracts and Patents

Certain of the following notes have been taken from *Nuclear Science Abstracts*, published by the United States Atomic Energy Commission, Technical Information Service Extension, Oak Ridge, Tennessee. Others are precis of U.S. patents and institution reports.

LMFRE in America

A preliminary design for the Liquid-Metal-Fuel Reactor Equipment (LMFRE) has been prepared by the American Babcock and Wilcox Company for the United States Atomic Energy Commission. The liquid-metal-fuel reactor concept is interpreted to mean a liquid-metal circulating-fuel thermal-breeder reactor, with a solution of uranium in bismuth as fuel. The moderator is bare graphite, and the breeding fluid is a slurry of thorium-bismuthide dispersed in bismuth. A plant of 200 MW electrical capacity is the objective. (A.S.M.E. report: R. T. Schomer.)

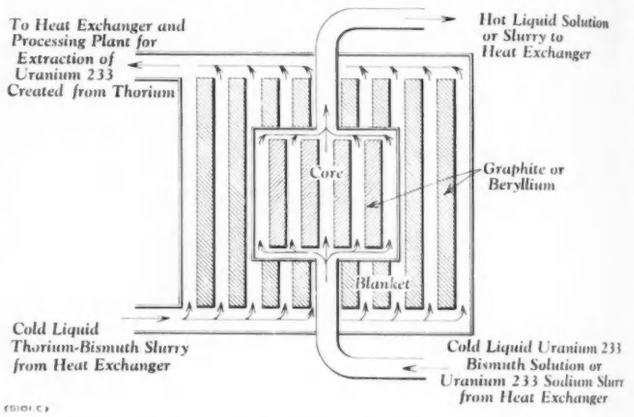

To Heat Exchanger and Processing Plant for Extraction of Uranium 233 Created from Thorium
Hot Liquid Solution or Slurry to Heat Exchanger
Core
Graphite or Beryllium
Blanket
Cold Liquid Thorium-Bismuth Slurry from Heat Exchanger
Cold Liquid Uranium 233 Bismuth Solution or Uranium 233 Sodium Slurry from Heat Exchanger
(5101.C)

Fig. 4 Layout of a typical liquid-metal-fuel reactor (LMFR), in which a uranium 233 solution or slurry is circulated through the core and a thorium slurry through the blanket. Research on this system is in progress in Australia.

Zero-Energy High-Temperature Reactor

As previously stated in Atomic Review, the General Electric Company has been awarded a contract for a large part of the design and construction of a zero-energy assembly for the high-temperature gas-cooled reactor. The HTGC reactor is a thermal breeder type, operating on the uranium233-thorium cycle, that is, fission is primarily due to slow neutrons and more atoms of fissile uranium 233 are produced than are consumed. The basic fuel is thorium. The reactor, which is being constructed at the United Kingdom Atomic Energy Authority's Establishment at Winfrith Heath in Dorset, will operate at temperatures of the order of 1,470 deg. F. (800 deg. C.).

High-Temperature Gas-Cooled Reactor

A design for an experimental nuclear power plant utilising a high-temperature gas-cooled power pile as the energy source has been developed. The plant consists of the pile, a heat exchanger or boiler, a conventional steam turbine generator, and their associated auxiliaries. Helium gas under pressure transfers heat from the pile to the boiler which generates steam for driving the generator. The plant is rated at a normal output of 12 MW of heat and an electrical output of 2,400 kW. Provision is made for operation up to 20 MW of heat (4 MW electrical) if operation of the plant proves this possible. The pile operates on thermal-energy neutrons using uranium enriched to 30 per cent. uranium 235 as fuel. It is a right-circular cylinder with its axis vertical and contains beryllium oxide as the moderating material and permanent skeletal structure. Removable fuel elements consisting of mixtures of enriched uranium and moderating material, which may be beryllium metal, beryllium oxide, or graphite, are located in vertical channels running parallel to the axis of the cylinder. Helium gas at a maximum pressure of 10 atmospheres flows through these channels where it is heated to a maximum temperature of 1,400 deg. F. (760 deg. C.). The hot gas is then circulated through a boiler where it is cooled and generates steam, thence is returned to the pile at a temperature of 500 deg. F. (C. Roger McCullough: Clinton Laboratories, Oak Ridge, Tennessee, U.S.A.)

Temperature Coefficient of Gas-Cooled Reactors

A graphite-moderated solid-fuel gas-cooled reactor does not have as large a negative temperature coefficient as is desirable. It has been suggested that a liquid-metal neutron absorber, forced into the core by thermal expansion, might produce the desired effect. For a reactor under consideration, an analogue simulation study indicates that the absorber should produce an effective temperature coefficient of reactivity of 5×10^{-5} per deg. F., with a time constant of 0·5 sec. or less. Two systems which might achieve these values of time constant and coefficient of reactivity have been studied. The first system uses a mild-steel reservoir filled with liquid cadmium. The expansion of the cadmium in the reservoir with a rise in temperature forces cadmium into the reactor. In this system, the walls of the reservoir must be 0·002 in. thick and a large part of the power output of the reactor must be used to pump the coolant between the plates of the reservoir. This system is not practical. The other system studied consists of helium in a stainless-steel reservoir connected to a manometer containing liquid cadmium. The reservoir of helium is heated by the coolant and the resulting thermal expansion forces the liquid cadmium in the manometer into the reactor. The walls of the reservoir in the helium-cadmium system could be constructed of 0·007 in. thick stainless steel. Only a small fraction of the reactor power would be needed to pump the coolant past the reservoir. (B. B. Gordon, J. J. Stone, and H. M. Epstein: Battelle Memorial Institute, Columbus, Ohio.)

Graphite Superheating Reactor

A design study has been made of a graphite superheating reactor, a graphite moderated reactor with a heat rating of 305 MW, which produces superheated steam. It is designed for the production of plutonium and electrical power or for the production of electrical power only. The fuel elements for dual-purpose operation are uranium metal, while for single purpose action, they are uranium oxide. The fuel elements are cooled by a 7-pass system in which preheated water enters the bottom of the first pass and is discharged as superheated steam at the top of the seventh pass. The reactor makes use of shim control by the gas system, vertical

gas-cooled control rods, vertical safety rods, and a ball safety system. Rough cost estimates indicate that the capital cost of the reactor should be comparable to other reactors of similar heat output. (R. M. Fryar: General Electric Co., Hanford Atomic Productions Operation, Richland, Washington, U.S.A.)

Superheater Reactor

A means has been proposed for circulating vapour through a reactor core, in order to superheat the vapour, in a reactor of the type having coolant liquid circulated through clad fuel elements geometrically arranged in a solid moderator, such as graphite, the core being enclosed in a pressure vessel and suitable shielding. Superheating is accomplished by drawing off the liquid which has been heated in the core due to the fission of the fuel, passing it through a nozzle into a chamber where it flashes into a vapour, and then passing the vapour through separate tubes extending through the moderator to pick up more heat developed in the core due to the fission of the fuel, thereby producing superheated vapour. (U.S. Patent No. 2,806,820: E. P. Wigner.)

Cooling Tower Reactor

A preliminary design has been made of a homogeneous reactor in which the heat is removed from the core solution in a packed or slatted cooling tower. In this tower a portion of the moderator is evaporated into a recirculating gas stream. This gas is cooled and a portion of the vapour is condensed in a heat exchanger producing steam. The operating conditions of the cooling tower chosen for a 50 MW reactor include a gas flow rate of 268,820 lb. of oxygen per hour and a total pressure of 700 lb. per sq. in. The inlet and outlet gas temperatures are 390 and 455 deg. F. respectively. The liquid enters the tower at 482 deg. F. and leaves at 416 deg. F. The required volume of packed tower, assuming a transfer coefficient of 600 B.Th.U. per hr. sq. ft. enthalpy difference, is 1,200 cub. ft. (Oak Ridge National Laboratory: J. P. Sanders and P. N. Haubenreich.)

Package Homogeneous Reactor

A preliminary design of a 10 MW power plant utilising a circulating fuel-type homogeneous reactor as the primary heat source has been completed. The power plant is designed to satisfy the military requirements of 1,000 kW of net electrical output and 3,800 kW of space heat. The package unit, containing the heat-exchanger and the core, is a removable element 17·5 ft. high and 6·67 ft. in diameter. Provisions for detachment of both this unit and the main pump internals have been included. Uranyl-sulphate (UO_2SO_4 with 93·5 per cent. enrichment of uranium 235 is used as the fuel and heavy water is used as the moderator. The initial uranium loading would be 7·62 kg. New fuel is to be added at short intervals after start up. The entire fuel loading is to be processed after five years of operation. (D. W. Montgomery, W. J. Dodson, F. F. Kaiser, W. K. Luckow and T. J. Pashos: Oak Ridge School of Reactor Technology, Tennessee, U.S.A.)

Flexible Plastic Reactor

A flexible accessible critical assembly, adaptable to rapid large-scale composition and geometry changes while retaining reproducibility and reliability of reactor measurements, has been designed by members of the Knolls Atomic Energy Laboratory, using a polyethylene matrix. The Flexible Plastic Reactor (FPR) provides a versatile inexpensive critical assembly for studying water-moderated reactors, and employs a polyethylene plus void structure to simulate the water moderator. Since the moderator is solid, a costly container is unnecessary, and there is access to both ends. Experiments have indicated that the nuclear differences between polyethylene and water have a negligible effect on the accuracy of critical assembly measurements. The entire cost of FPR was 230,000 dols., and core materials such as polyethylene, aluminium, borated polyethylene and cadmium, cost a further 30,000 dols. The Knolls laboratory is operated for the U.S.A.E.C. by the American General Electric Company. (American Nuclear Society paper: S. W. Kitchen and others.)

Wire Cloth Core FBR

From a preliminary evaluation, it has been concluded that the use of wire cloth as a fuel-bearing medium holds great promise of meeting the various design criteria of a fast breeder power reactor core. The geometrical properties of wire cloth permit a wide choice of wire diameter and wire cloth mesh to meet a desired porosity and heat-transfer requirements. Preliminary metallurgical studies indicate suitable fuel enrichment may be achieved and that the fuel-bearing matrix can be formed into wires with suitable weaving properties. Eventually, remote wire drawing and wire cloth weaving appears feasible. Core compositions can be obtained that require relatively low critical masses of fuel. Pressure drop through the fuel bed can be completely controlled by varying the number and thickness of annuli. The steam temperature is strongly influenced by wire diameter and the thermal conductivity of the fuel-bearing matrix. Thermal conductivity data is required before the design can be optimised. Effects of low thermal conductivity can be overcome by use of small wire diameters. (B. W. Ela: California Research and Development Corporation, Livermore, California, U.S.A.)

Flattening and Conversion Ratio

The problem of a flattened core versus a uniformly loaded core for breeder reactor projects has been re-examined. Several flattened core designs were carried through criticality and power calculations in order to obtain the conversion ratio as a function of critical mass for a given production rate. These results were compared with previous work on uniformly loaded reactors of the same assembly design and heat transfer limitations. The results of the study indicate that the flattened reactors yield higher conversion ratios than uniformly loaded reactors at low critical masses, and uniformly loaded reactors yield higher conversion ratios at higher critical masses. (Ralph Balent: North American Aviation Incorporated, California.)

Notes and News

Reactor Physics at Battelle

A reactor physics division has been established at Battelle Institute, Columbus, Ohio. One of its primary functions is to co-ordinate the increased volume of reactor research now under way at the Institute. The reactor physics division will conduct research in four major fields of nuclear technology. These include radiation effects and exponential experiments using Battelle's 1 MW (thermal) nuclear reactor, reactor design development through critical experiments, theoretical reactor design analysis, and heat-transfer studies. Battelle reactor physics research is complemented by research on reactor materials and metallurgy, fuel-element development, and radiochemistry, with a volume of more than 5 million dols. in 1956.

Zeta Dismantled

It is reported that Zeta has now been dismantled and may not be restored to operation until the end of this year. The interior of the torus is being examined for damage. It is stated that the two main transformers which embrace the torus are to be moved closer together, taking up an inch clearance that previously existed. Condenser capacity is also to be increased. The object of the alterations is to attain temperatures in the region of 15 million deg. C. during the next series of experiments.

Zeta Model for Brussels Fair

A model of Zeta, 7 ft. high, in which the Harwell thermonuclear experiments will be illustrated, is to be installed in the British Government Pavilion at the Brussels Universal and International Exhibition in April. The Brussels model, which will be in the technology and science section of the British Government Pavilion, will be built to a one-third scale of the original. Its torus (the ring-shaped cylinder) will be made of Perspex so that the interior flash can be seen at 10 second intervals.

Soviet Thermonuclear Work

Several groups of Soviet scientists and engineers are working on the design of thermonuclear reactors, according to Academician I. V. Kurchatov writing in an article in *Pravda*. Temperatures in the region of a million deg. C. had already been obtained using a current of 2 million amperes. Neutron emission had been recorded. A full report of Academician Kurchatov's earlier work in this field was published in ENGINEERING, vol. 181, page 322, 1956. One Soviet thermonuclear apparatus is believed to be of torus design. Academician Kurchatov also stated that deuterium separation was carried out by deep-freeze methods using temperatures of — 250 deg. C. More extensive results were, he said, to be published at the International Conference on the Peaceful Uses of Atomic Energy to be held in Geneva next September.

Insurance Conferences

Last week insurance representatives from 14 European countries attended a three-day conference in London, as guests of the British Insurance (Atomic Energy) Committee, to discuss problems concerning the insurance of nuclear reactors. Reference to the Committee was made previously in Atomic Review last February 21 and July 5, 1957. The address of the British Insurance Association is 59-67 Gresham-street, London, E.C.2.

The United States Atomic Energy Commission held an industry advisory conference with insurance company representatives last January 31 to consider a proposed amendment to its temporary indemnity regulation. The amendment is designed to serve as a basis for calculating financial protection which persons licensed to operate a nuclear reactor must have.

Insurance Study in the United States

The Harvard Law School has undertaken a study of the international aspects of providing financial protection to the public and to industry against the possibly catastrophic losses which might be caused by a serious atomic industrial accident. The study is supported by the Atomic Industrial Forum, Incorporated, an association of business firms and organisations interested in atomic development. The possibilities, however slight, of catastrophic losses in the event of a serious atomic industrial accident constitute a major obstacle to the development of the peaceful uses of atomic energy on a wide scale. It has been a matter of international interest and is already under study by Euratom and the O.E.E.C. (Organisation for European Economic Co-operation). Within the United States, the problem has been largely met by the Anderson-Price Act recently passed by Congress, which provides a government indemnity of up to 500 million dols. over and above available private insurance.

Unified Field Theory

Speaking in Göttingen last week, Professor Werner Heisenberg stated that he and his colleagues had developed an equation or set of equations that reconciled in one concept electrical, magnetic and gravitational fields. When confirmed, the formula would serve as the basis of a unified field theory, which had been sought by Einstein and other physicists for more than 30 years. In formulating the equation, use had been made of the findings of Dr. Tsung Dao-lee and Dr. Chen Ning-yang, who won a Nobel Prize last year for their work on parity at the Princeton Institute of Advanced Studies. This work was discussed in Atomic Review last April 26, page 538. (Comment on Professor Heisenberg's results appears in Weekly Survey.)

The Human Element

Cold Shoulder for Cohen

The trade unions are on the war path and determined to scotch the Cohen report, and the Government has helped them a little in reaching their objective. The point which every trade unionist has seized upon is the statement that "a free and flexible economic system cannot work efficiently without a perceptible margin of unemployment." Yet this is precisely what the experience of the past decade has taught everyone. The matter was the subject of an acrimonious debate in the House, which showed clearly enough that the rising unemployment figures are wronging everybody. However, there is something to be said for the view of a correspondent to the *Observer;* the writer referred, scathingly, to an unsuccessful litigant who described the decision of a judge as partisan.

The Government appeared altogether unwilling to embrace the findings of the Cohen report and it is likely to be quietly shelved, at any rate while the unemployment rate continues to rise. Mr. Macmillan put the issue fairly enough when he told an Independent Television audience that what was needed was a balance in this as in most other things: Unemployment, he said, should not be a "deliberate instrument" of policy. "On the other hand, inflation and five jobs for every three men is bad for discipline, bad for trade unions."

The T.U.C. General Council met to consider the Cohen report and unanimously endorsed the criticisms made earlier by individual leaders. It was described as "partisan" and "unimaginative" and the Council indicated it would have nothing further to do with Lord Justice Cohen and his two colleagues. The meeting was held in an atmosphere of militant expectations and many threats were uttered. It seems that circumstances are against the moderates and this could have disastrous results.

Feminine Touch

Youth employment officers are increasingly looking to the so-called weaker sex for recruits to the engineering industry. The Ministry of Labour's Central Youth Employment Executive have just published an attractive booklet in their *Choice of Careers* series which illustrates the many varied occupations for which girls are well fitted. One figure quoted in the introduction will surprise many—over half a million women and girls are employed in all branches of the engineering industry, approximately one-fifth of all engineering workers. They are employed, the booklet says, "mainly on light and delicate work for which deft fingers are needed." It could equally aptly have said "where patience and loving care is needed," for girls are generally more painstaking and more conscientious in the execution of routine than men. There is no doubt that the experience of two wars has shown that girls can do many engineering jobs, and on some jobs are better than men.

An illustration of this point is to be found in South Wales, where women and girls are employed in relatively large numbers on hand rolling mills and on various finishing operations in the production of high-quality aluminium sheet. The closure of several tinplate mills has thrown men into unemployment and their unions are pressing the management to dismiss their female labour to give men jobs. The reason put forward for resisting this is precisely that underlined in the booklet, namely, the girls get better results, a lower proportion of scrap (which is most expensive in this trade) and are more patient with the slow monotony of hand rolling.

Separate sections of the booklet describe jobs in making component parts, assembly work, and testing and inspection—work learned mainly by girls who leave school at 15. One section touches on work for older school leavers, including training and apprenticeship for the skilled crafts, work in laboratories and drawing offices, and other more advanced work in research and design. The booklet is well illustrated and attractively presented and should be well received by the girls and their teachers alike.

Lions and Lambs

A conference was organised last week-end by the Industrial Welfare Society called "Conflict or Co-operation?" It was for foremen and shop stewards, and the work of the conference revolved round three papers—two by industrialists and one by a trade unionist.

There is a great need for increased co-operation in industry at the foreman-shop steward level—a fact which was emphasised in the trade-union paper. The co-operation as yet achieved on the shop floor between the foreman and shop steward is rudimentary. It is indeed about fifty years behind the stage of development reached at the highest levels of industry and trade-union organisation.

Despite its limitations at times the relations between industry and the unions at the top of the organisational tree, that is, at the national level, are fairly good. On the shop floor, the foreman is often struggling for existence against certain trends of development in management, and the shop steward is often in a not dissimilar position on the union side. Both sides may therefore be on the defensive before they come into contact with each other and this is not a good beginning. In other words, there is a need for confidence by both sides of industry in their accredited representatives if they in turn are to get on with each other. These basic issues must be dealt with before high-flown talk about co-operation between management and labour begins to mean very much.

My Brother's Keeper

A paper presented to the Association of Supervising Electrical Engineers by Mr. P. W. Cole was called "Prevention of Accidents: the Legal Responsibility of Supervising Engineers." His talk covered mainly the question of responsibility in civil law but certain questions of criminal law were also mentioned, particularly those concerning the liability of owner-occupiers and workmen in relation to statute law.

It is the question of legal responsibility as a civil wrong which is probably the most confusing, however. Where a duty exists to take care, then where there is failure to do so, negligence in a legal sense may ensue. Degrees of care required vary and the law keeps clear of precise definitions on the subject to allow the application of the principles to as wide a range of circumstances as possible. One of the significant developments in the law of recent years has been the exposure of supervising employees of an organisation (for example, a nationalised industry or a large company) to claims from injured employees under their supervision for damages and also liability for recovery damages where claims have been successfully made by an injured employee against the employer.

One way and another, the interest of the technical man in training his staff in good safety precautions and supervising them himself is becoming not only a question of ethics and economics. It has now become a matter of self-interest. Any engineer who is worth suing may be to-day in a vulnerable position if his subordinates do not take care in their work. "Care" is an imprecise word in law but good safety precautions and concentration are desirable substitutes for a legel definition in a particular case.

Men Without Jobs

During the early part of February there was an increase in the numbers unemployed to 1·9 per cent. of the working population. This was a rise of 0·1 per cent. on the month and could not be accounted for by the seasonal pattern of unemployment. It was equivalent to an increase of 28,000 unemployed and brings the total close to 2 per cent. which in round figures is 500,000 unemployed. A total of this size is a handy one to bandy around at the hustings, though to the experts there may be nothing very alarming about 2 per cent.—or so presumably the Cohen Committee thought.

The rise has coincided with the news that the official index of industrial output for January has reached stagnation point. It is not surprising, therefore, that there have been sounds from the Government about a possible reversal of economic policy in the early spring. All along such a change was a question of timing and it remains so. This year the Budget comes perhaps a little early for confident economic crystal gazing but it is almost certain that the Government's views on future policy will have to harden before the Budget is presented at the beginning of next month.

Training Technical Teachers

The three Technical Teacher Training Colleges at Huddersfield, Bolton and London are engaged in a recruiting drive to fill increased vacancies. For the past ten years these colleges have had at their disposal only some 350 places but there is now an increase of 60 per cent. in the possible intake. This occurs at a time when there has been a big increase in the value of grants available. The course lasts for one year and falls under two main headings—general principles of teaching, and English and speech training. Teaching practice is given in two six-week periods in technical colleges.

On the supply side of technical teaching there are signs of a good deal of interest in such a career by members of the armed forces. A letter has recently been sent out to local authorities giving the arrangements made for assessing grants payable to ex-Service personnel while undergoing training. Grants are free of income tax but they are assessed on income. Maximum grants cover free board and lodging during term, a day maintenance grant for day students, free tuition, a personal grant, a travelling grant and a dependents' grant in the case of one-year courses only. These arrangements may be revised with effect from Autumn, 1958, as a result of the triennial review of rates now taking place.

Nuclear Powers

Negotiations began last week on a claim for substantial salary increases for nuclear scientists and engineers which was submitted to the United Kingdom Atomic Energy Authority by the Institution of Professional Civil Servants about a month ago. This promises to be a hard fight between Mr. Stanley Mayne, the general secretary of the Institution, and Sir Donald Perrott, the member of the Authority responsible for finance and administration.

The case for the increases has now been presented. The biggest demand is for an increase of £2,350 a year for senior scientists but the claim embraces all grades, from senior scientific and principal officers to experimental assistants—8,000 scientists and technicians in all.

STRESS AND STRAIN IN HUMAN RELATIONS

By Z. M. T. Tarkowski, B.SC.

Good communication is essential both for productivity and for good human relations. It is also necessary if technical problems are to be adequately discussed and grievances aired. Previous articles discussed, in terms and analogies familiar to engineering, the difficulties of the person who does not fit in and the problems he creates for his organisation. It was shown that a number of feedback paths are in operation and that the understanding of them facilitates solution of the problems. In the present article a further connection is shown between stress of life, physical health, and problems of face-to-face communication, by means of a comparison with an automatically controlled system.

It is almost a commonplace to say that managers live and work in a state of considerable stress. Psychosomatic illnesses are common among business executives at all levels. They are often attributed to overwork, but their main source, as is becoming slowly acknowledged, is in the competitive relationship with colleagues at work, in a personal rigidity leading to the difficulty of accepting change, and very often in an unsatisfactory home life.

To enjoy an expense account for entertainment is a sign of success, but, as a result, the modern executive in the western world has less and less leisure and opportunities for peaceful and relaxed social life. A great amount of business is done over lunch and even if the occasion is seemingly a sociable one, the strain of negotiation, guardedness and manoeuvring for position is always present. In some instances, a man of affairs may be booked up for luncheon appointments several months ahead, with no respite, which means that his rest period is lost. There is no time to escape from the pressure of work, to take a leisurely stroll round a square or a park, or to sit peacefully on a bench.

It is not possible to listen to a lunchtime concert, a lecture, to visit a picture gallery or perhaps a church. It is not easy to meet a friend on the spur of the moment, to talk freely, because the friend is equally taken up with luncheon appointments. Even worse, a new convention is being added to the already cramping list of existing ones: in many circles it is not done to ring a business friend suggesting a luncheon meeting on the same day—and the custom is spreading, at least in big cities. This applies particularly to senior people in sales and publicity, but it affects others as well.

Not that one can relax and be free with friends as one used to. In all walks of life the general bidding for prestige, the window-dressing and the necessity to keep up with them are such that plain speaking, frankness and sincerity are more and more difficult, almost impossible. It is necessary, for one's success, to build up and maintain a facade of bonhomie, and at the same time to score off by what is virtually disguised boasting, consisting of more or less subtly veiled hints.

This attitude is adopted not only in business functions but also in what used to be one's leisure and social relaxation. Furthering of one's career becomes the sole purpose of so-called entertainment—for host and guests alike. There is no rest; an incautious word may be prejudicial to one's advancement. Constant vigilance makes life more and more difficult.

In this way people become increasingly isolated from each other. The sense of companionship and mutual understanding is lost. In spite of apparen camaraderie, in spite of a facade of bonhomie—which is the necessary ingredient of success in the society of "good mixers"—everybody is waging a lonely fight. The facade covers up a great deal of insecurity, and as a result people are increasingly guarded and more and more easily alarmed. This increases the necessity for the further building up of the facade and makes the apparent bonhomie still more superficial.

The nature of the situation makes it imperative to establish the value of one's own pet schemes by insinuation and undermining the pet ideas of others. This is nerve-racking, and in the heat of disguised but deadly rivalry nobody is able to pay attention to the real merits of the case. Stress at the top transmits itself downwards.

In this atmosphere, frankness and sincerity are out of place. They give the game away and so undermine the security of those for whom it has become a convention and a way of life. The more unconscious the gamesmanship, the greater the reaction of embarrassment or irritation when the rules of the game are infringed. Those who are outspoken are likely to become bad mixers.

And yet, as has been pointed out,[11] plain speaking and sincere criticism are indispensable if friction between groups and individuals is to be smoothed out. They are also necessary for adequate discussion of any innovation or technological change which may be suggested. Frankness and sincerity are, in fact, essential conditions of good communication between people, and when they are absent the quality of discussion is impaired. This puts a brake on progress and modernisation, and is bound to lead to inefficiency. Lack of good communication and absence of sincere discussion result in being left behind in competition with more alert organisations at home or abroad.

THEORETICAL ANALYSIS

In order to understand the phenomenon of stress and the way it affects communication between people, we shall have to examine in some detail what happens when a person or an animal is exposed to danger.

When a predatory animal appears within the field of vision, the organism sensing it undergoes various changes which have been called *emergency* or *alarm reaction*. The sight of a beast of prey is only one example of what may be generally called a *danger signal*. As is well known, when a danger signal impinges on the ordinary avenues of sensory input, that is, eyes or ears, the alarm reaction produced in the animal or human organism consists primarily in the injection of adrenalin from the adrenal gland into the blood stream. This results in the blood supply being redistributed. The provision of blood for the surface of the body, the digestive system and also, it would seem, for certain parts of the brain is curtailed, whereas there is a more abundant flow to the skeletal muscles, which subserve physical movement such as escape or attack. The digestion is temporarily suspended and, in human beings, there is a tendency to facial pallor. We know from experience that in a state of danger clear thinking about difficult matters becomes almost impossible, and a certain amount of physiological evidence leads to the suspicion that the alarm reaction involves impairment or suspension of the higher cerebral functions. On the other hand, the skeletal muscles react more speedily to the impulses or instructions coming from the nervous centres subserving the organisation of attack, defence or escape. Also, the average rate of expenditure of energy becomes higher than under ordinary conditions, but the adrenalin, together with other hormonal substances, is used up by muscular action and, if the danger is in the meantime escaped from or averted, the organism returns to the normal rate of expenditure of energy.

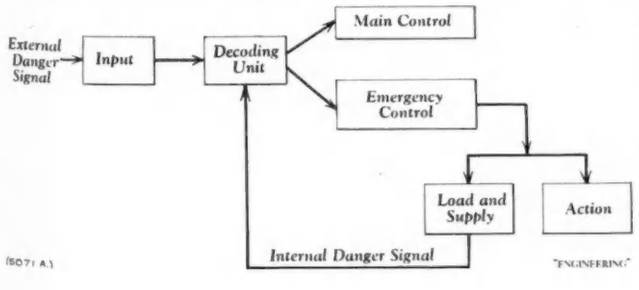
This description of alarm reaction is oversimplified, but it will be sufficient for our present purpose. In order to carry the analysis further and to bring out the important points, let us compare the physiological system, that is, an animal or human organism, to an automatically controlled unit such as an automated factory directed by a computer.

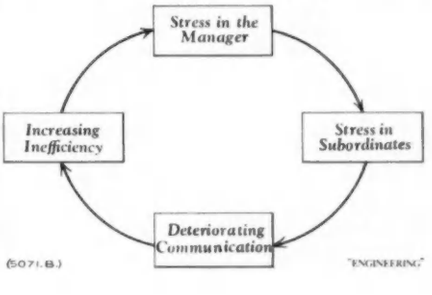
The stimuli, or messages, from the external world impinge on the Input (see diagram), comparable to the eyes, ears and skin senses of a living organism. They are read and interpreted by the Decoding Unit and then, in ordinary circumstances, passed on to the Main Programme or, in the case of an analogue computer, on to the Main Control Unit. The differences between a digital and an analogue computer are for our present purposes immaterial.

If the input is interpreted by the Decoding Unit as a *danger signal*, it is directed to the Emergency Control, which takes over from the Main Control. The Main Control, apart from its other functions, which we shall neglect for our present purpose, regulates the distribution of load and supply to various parts of the system, keeping it within normal running conditions. The reorganisation affected by the Emergency Control is such as to ward off the external danger, and it imposes, for a limited period of time, higher loads than are normally permissible. This means that the system working under emergency conditions too long may suffer damage, and, in any case, various regulating mechanisms alter their characteristics. The resulting loss of calibration is likely to lead to hunting or jamming and to general instability.

To attempt to formulate briefly a modern physiological theory, the state of stress results from a prolonged alarm reaction. If that is present it will be clear from our analogy that it must lead to instability. There is also a strong indication, speaking in terms of our analogy, that the internal strain due to an excessive period of overloading acts as an internal danger signal which is fed back to the Decoding Unit. If it reaches a certain level of intensity it is reasonable to suppose that a positive feedback circuit is established, as a result of which the Emergency Control is functioning permanently and not intermittently. Thus, the state of stress is maintained or even built up indefinitely. To use the terminology of some psychological writers, the state of *stress* or *alarm* (or *anxiety*) may require *functional autonomy*. This corresponds to an insight familiar to many people, that is, that *anxiety feeds upon itself*.

Furthermore, as we all know, a person who





Production

IMPACT EXTRUDING STEEL

Impact extrusion is a very familiar production method for certain types of article, such as toothpaste tubes and similar collapsible or rigid containers, millions of which are made every week. The emphasis at present is chiefly on aluminium and other non-ferrous metals, but the process has been extended to the ferrous metals, and in this field it is developing very quickly. Mr. W. H. Byles, in a paper delivered recently to the Coventry section of the Institution of Production Engineers, forecast an increased use of the process on steel, and said that it may well cover a wider field than that already occupied by non-ferrous extrusion.

As Mr. Byles pointed out, impact extrusion has some impressive features compared with other methods of component production. It is basically simple, and has the important advantage that there is no wastage of material. In most cases, the volume of the blank is the same as that of the finished component. Even if trimming is necessary after the press operation, only a very small percentage of metal is lost. Another advantage is that grain flow is related to the shape of the part by the plastic deformation which takes place in the press. Finally, speed of production is high. It is often possible to produce components at a rate equal to the number of strokes per minute made by the press; in favourable circumstances this may be 60 to 100.

Large numbers of components are already being produced in steel by impact extrusion; they include various types of power cylinders, gudgeon pins, needle bearing cups and many other components. Most commercial steels can be worked cold, to some extent, in their fully-annealed condition. Steels in the low carbon range are usually employed because in many instances they show, after cold working, physical characteristics equivalent to some of the higher grade steels. Impact extrusion of steel is in accordance with the same basic principle as that of non-ferrous metals, the main differences being in the method of preparation of the blanks or slugs, lubrication, tool design and pressures. Blanks are usually prepared from bar stock by cropping, sawing or parting-off. Cropping is simple and economical, but because of distortion and work-hardening it may be necessary to add a sizing or annealing operation, or both. However the blanks are produced, it is true to say that the better the blank the better the finished component. A surface treatment, usually phosphate coating in combination with a lubricant, is necessary. This surface treatment is of great importance. Breakdown of the protective coating will cause seizure between the metal of the component being produced and the tools; this will raise the pressure dangerously, and will probably lead to tool failure.

Impact extrusion, now being increasingly used for steel parts, offers the advantages of economy of material, improved grain flow and speed of production.

Pressures required for steel extrusion depend on several factors, including lubrication, extrusion speed, and the degree of change or reduction of cross-sectional area of the component. The pressures are, of course, generally much higher than those used for non-ferrous metals. Extrusion speed is subject to speculation. Speeds suggested vary from 10 in. to 30 in. per second, but a lot of work has been, and is still, carried out at much lower speeds. Plain cylinders, of constant wall thickness are probably better suited to higher speeds, and some authorities claim that shallow, relatively thin parts, with changing cross-section and increasing area, should be pressed slowly. The degree of reduction in area which can be obtained in one operation depends on the characteristics of the material. Whereas with pure aluminium reductions of the order of 99 per cent. are possible, this cannot be done with steel, and the general opinion is that for the best results the optimum is between 55 and 70 per cent.

Tool design is a vital factor, and it is here that a considerable amount of "know-how," which can only be gained by practical experience, is necessary. The tool and product designers should collaborate closely, as it is sometimes possible to simplify the tool by means of small changes in component design, which do not affect its functioning. Press design is also important. It is true to say that almost any press will produce parts of a kind within its capacity, but the results can be indifferent and tool life poor if a press is lacking in certain essentials. Of particular importance are press rigidity, power and some degree of speed control.

Presses designed for this class of work are now becoming available. They may be of the single-stage type, with automatic feed if required, or of the multi-stage or transfer type, which is now finding application for extrusion or for combined extrusion and upsetting. The latter type is as yet only suitable for small parts.

The whole process of impact extrusion is developing, and Mr. Byles forecast an increasing contribution to engineering production generally, particularly in the car and cycle industries.

Continuing The Human Element

is already anxious or frightened will react with a further increase of anxiety to events which, in ordinary circumstances, would not disturb him at all. Thus, it is reasonable to suppose, in terms of our analogy, that in an emergency reaction and, even more so, under the condition of stress, the feed-back from the system to the Decoding Unit leads to its reorganisation. This is such that more and more messages come to be interpreted as danger signals, even if they are only routine type of stimuli which under normal conditions would not have produced the emergency state. If follows, therefore—to return to human beings—that not only does the anxiety or stress feed upon itself, but, once its functional autonomy is established, it seizes on external events to build itself up still further.

When a man is caught in this form of vicious circle, words, phrases and gestures of other people become progressively misinterpreted. Innocuous jokes, sincere criticisms or suggestions, come to be treated as offences. There is a general loss of patience and understanding and increasing inability to communicate.

A senior man deprived of rest and peaceful relaxation and involved perpetually in a bitter struggle for further advancement is bound to live in a condition of severe stress, and his vulnerability and touchiness, his lack of patience and understanding, will unavoidably induce anxiety and stress in his subordinates. An atmosphere of mutual suspicion, irritability and resentment will inevitably pervade a whole group of people and result in deteriorating communication and progressive inefficiency.

APPENDIX

The ever increasing pressure on senior management in industry has been recently discussed by Alexander Kennedy,[1] who also considers individual reactions to change, their medical implications and their effect on industry as a whole.

The progressive deterioration of personal relationships has been strongly emphasised by John Marsh.[2] The effect of the resulting emotional isolation on executive behaviour and efficiency has been recently examined in some detail.[3]

The *emergency theory* of emotional reaction to danger was first proposed by W. B. Cannon[4]. His book is still a classic on the subject although the details of Cannon's theory are being disputed or developed by various writers. Useful references can be found in a paper by Magda Arnold.[5] The description of the vasomotor effects of adrenalin—or *epinephrine* as it is called by some writers—can be found in Fulton,[6] and a more complete and up-to-date account in Barcroft and Swan.[7] It is now known that at least two different substances are involved, adrenalin and non-adrenalin (or *nor-epinephrine*) and according to Barcroft and Swan[7] the latter has definitely a vasoconstrictor action on certain parts of the brain, which is bound, it would seem, to impair their performance.

The advantages to be derived from using comparisons, analogies and models in physical sciences and in psychology are being examined elsewhere.[8] The idea that the action of an internal *stressor* (i.e., the cause of stress) may be similar to that of an external one is due to Hans Selye, who has developed a very interesting but somewhat controversial theory of stress. It has, however, very great relevance to psychology. A readable introduction can be found in his latest book[9] which contains references to his more technical publications. The concepts of *functional autonomy*, the *vicious circle* and *irritability* have already been discussed.[10,11] An interesting introduction to recent experimental work can be found in H. G. Wolff.[12] A well-written account covering the whole field, easily understood but up-to-date and sufficiently technical, is provided by Hamilton.[13]

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INERT-LAYER PROCESSING

A new technique, the "Serseal" layer process for the elimination of fumes and steam from aqueous metal-treatment baths and for reducing heating costs has been introduced by the Paints Division of Imperial Chemical Industries Limited.

The process seals the surface of a processing liquid contained in a bath with a layer of inert material. It was developed for use in baths producing heavy phosphate coatings but other grades are now available for acid and alkaline vats.

Management

FREE TRADE FROM MANY ANGLES

European Industrial Conference Clears the Air

It is probable that no one expected anything very new to be said at the European Industrial Conference held at Church House last week. Indeed there were many among the enthusiasts for European integration who doubted the wisdom of the United Kingdom Council for United Europe in holding a conference at this stage of the negotiations. There is no doubt that the Conference suffered greatly from the fact that details of the French plan for a free trade area were not known. The result was that far too much time was taken up in going over the well worn arguments. Nevertheless, the Conference produced some interesting speeches.

United Kingdom Government View

The arrangement of the programme was such that all the main speakers appeared on the first morning. The Chancellor of the Exchequer said that the difficulty of trying to combine the different techniques of the Customs Union (common external tariff) and free trade area had produced " tough and complex problems." Changes in industrial methods and in the pattern of trade would be inevitable. But, said the Chancellor, in post-war Britain some industries had expanded, others like cotton, had declined. The changes that were coming would be " salutary, tending to higher efficiency and greater fitness to survive, compete, and expand " in a world where industry and trade are changing more rapidly than ever before. Britain pays a heavy price for her dual function in world trade. " We throw open our markets to the entry of Commonwealth goods and carry the exacting role of world banker in more cramped circumstances than when we so easily assumed it in the Nineteenth Century." The British economy is under pressure because gold reserves serve as backing for half the world's trade and payments, and because the under-developed countries of the Commonwealth hold their reserves in sterling. Mr. Amery stressed the fact that the Common Market was a political idea and that a division between " friends and partners " in Europe was a risk not to be run.

The French Position

M. Robert Schuman attended the conference not as a member of the French delegation but as International President of the European Movement. His speech emphasised the differences between the British view and that of the Six. The Rome Treaty was a firm achievement, as important in its way as the British Commonwealth. There could be no question of modifying it. The only question was whether a bridge could be built between the Six and the other O.E.E.C. countries. After tracing the development of economic integration in Europe M. Schuman gave the conference its greatest shock. He stated that O.E.E.C. had exhausted its means of action, that it could not achieve any further useful purpose, and that what it had done so far was in any case fragmentary and precarious. For this reason the Six had taken the United States as their model in working out their plan for a United Europe. Inevitably greater cohesion for the Six meant discrimination against other nations. But, said M. Schuman, this is exactly what the British Commonwealth does, at least from the economic point of view. However, union for some does not mean a fight against everyone else. The question for the Six was whether they could belong at one and the same time to the Common Market and Free Trade Area.

M. Schuman believed that the fundamental difference between them was that the Six were not simply a low tariff club but were forming an economic union with a common economic policy. Such a union does not follow automatically from free trade. It requires compulsory rules, harmonisation of social policies and strong central institutions. If the same principles were applied to the Free Trade Area it would mean taking the clauses of the Rome Treaty as a basis. But with the wide differences between the O.E.E.C. countries was a sufficient degree of cohesion possible?

View of the Labour Party

Mr. P. G. Gordon Walker's contribution was interesting both because he replied to the points made by M. Schuman, and re-stated the Labour Party view on European free trade. He began by discussing the French position. Many people in France, including official bodies such as the Conseil Economique were bitterly opposed to the Free Trade Area. M. Schuman had assumed the existence of a " natural contradiction " between the idea of a common market and that of a free trade area. The European Economic Community, he had stated, had political rather than economic objectives. In Britain we had a real understanding of the French position, but Mr. Gordon Walker wondered if the British position was as well known in France. The idea that Britain wanted a free trade area simply because she could not afford to stay out was wrong. Britain had not taken up a negative attitude but had come into the Free Trade Area for positive economic and political reasons.

There is agreement between the political parties that Britain cannot join the Six in the European Economic Community. Although quick progress must be made in the negotiations it was not right to say that we had to go in on any terms. If the negotiations broke down the result would be that we should have to stay out or be kept out. Either way would be a disaster for Britain and we should have no choice but to use our position as Europe's greatest single market for agricultural produce, to gain advantages elsewhere. This step would have grave political consequences and would divide Europe but we might be forced into a position where we would have no other choice. It would be truer to say Europe cannot afford to have Britain stay out, than to put the choice the other way round.

After this attack on the French position Mr. Gordon Walker went on to re-state Labour Party policy. The Party believed that the State had a positive economic role to play. They thought that there would be great advantages of scale for industry in a free trade area, but this was not the same as a belief in the virtues of uncontrolled *laisser-faire*. State power can be used to frustrate the working of a free trade area by offering subsidies and other devices. Proper safeguards must be taken against this. But the activities of free enterprise in setting up cartels and other arrangements must also be guarded against. " To be quite frank," said Mr. Gordon Walker, " it is not so much competition that we fear as unemployment." The T.U.C. and Labour Party urge that there should be specific commitments to full employment in any treaty or arrangements made for a free trade area.

We must retain adequate rights to deal with balance of payments problems arising as a result of efforts to maintain full employment. In controlling the Free Trade Area majority votes would be accepted on " factual or judicial " matters, but the Labour Party would be reluctant to accept them on measures dealing with a balance of payments crisis. At home the Government should not be denied powers needed to plan the economy in the interests of full employment, stable prices and high investment. The power to control the location of industry, and within agreed limits to aid essential industry, would also be necessary. This need to retain effective control over the economy was one reason why we could not enter the Common Market. The other was the importance of maintaining duty-free entry of Commonwealth goods and of concluding, under GATT, long-term agreements for the buying of Commonwealth commodities.

These are not only economic considerations but are linked with the political and constitutional unity of the Commonwealth, and that is as important to the free world as the achievement of unity in Europe.

The Trade Unions

The fact that little has been heard of trade-union views on the Free Trade Area proposals since the publication of the T.U.C.'s policy statement in November, 1956, gave interest to the statement by Mr. J. Alan Birch, chairman of the Economic Committee of the T.U.C. The T.U.C., he said, agreed that Britain could not join the Common Market but should take part in the move for greater co-operation. Of the fundamental problems involved the Trade Union Movement placed the raising of living standards first together with the promotion of full employment, which is " the single most important objective which the workers in all European countries " have in common. The T.U.C. had submitted to the United Kingdom Government suggested draft clauses on the obligation of member countries to maintain full employment.

The T.U.C. considered that each Government should publish an annual report on its full employment objectives and policies. The Free Trade Area Treaty should emphasise the need for Governments to have power to influence consumption and investment and secure a balanced distribution of industry. Each country should develop a national employment service dealing with placing, training and the publication of information.

Mr. Birch thought that the problems of change should not be exaggerated. If industrial expansion continued the gradual introduction of changes over the next 12 years need not impose an unbearable strain. Special regard would have to be given to the industries hardest hit by change. One way to do this might be to vary the application of tariff reductions within a general framework. Governments should be ready with plans to help displaced workers with adequate unemployment pay, re-training facilities, support during re-training, and where necessary grants to help workers and their families to move to new areas. Governments should also have the right to use planning controls to take industry to the workers. Adequate arrangements for consultation between Governments, the central institutions and trade unionists must be written into the Free Trade Area Treaty.

Industrialist's View

Lord Knollys, chairman of Vickers Limited, agreed that the basic motives behind the free trade area were political. Nevertheless it will be industrialists and trade unionists who will have to be convinced that it is all worth while, and eventually make it work. The potential benefits to industry as a whole were great enough to justify the sacrifices that some firms and industries would have to make, and some important industries would undoubtedly be hurt.

Apart from the plenary session the 50 industrialists and 35 trade unionists from 14 continental countries spent a day working in commissions which discussed the major problems in greater detail. In addition, they had the advantage, common to all conferences, of informal meetings between sessions. It seemed clear that the impasse, implicit in M. Schuman's speech, did not prevent cheerful and friendly conversation between delegates, at least in their off-duty moments.

Book Reviews

LAYING OUT OPERATING THEATRES

Operating Theatre Suites. Hospital Building Bulletin No. 1. Prepared by Ministry of Health and Department of Health for Scotland. *Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2.* (9*s.*)

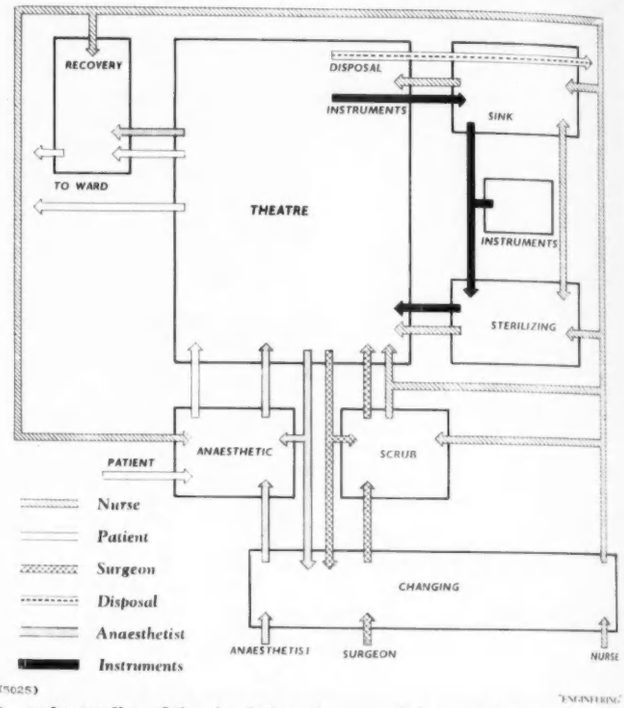
This is the first of the Hospital Building Bulletins. They are published by the Ministry of Health and the Department of Health for Scotland with the intention of giving help and guidance to those who are concerned with the design, planning and costing of hospitals. It is suggested by the Ministry that the bulletins should be based on the study of current practice in the United Kingdom and abroad. The purpose of the first bulletin is to give the principles on which operating suites should be designed in order to function well, and to meet the requirements of those using them.

After discussing such points as location and grouping of the operating theatre buildings, diagrams of a variety of layouts of operating suites are given and briefly described. This is followed by a description of possible layouts in various rooms in an operating suite. The engineering services, such as heating and ventilation, electrical installations, sterilising equipment, hot and cold water services, telephones, clocks, fire fighting equipment, etc., are also discussed in general terms. Finally the bulletin makes an analysis of the probable cost of buildings and the various engineering services. A list of relevant references is given, and a most detailed index to the text concludes the bulletin.

In the very early days when the National Health Service was introduced it became apparent that a great deal of effort would have to be made by the Government to secure and maintain the efficient running of the Service without unjustifiably high expenditure. The first bulletin appears to be one of the results of this effort. With this in mind, one would expect a publication of this nature to adopt a more positive attitude towards its subject, and to suggest definite solutions to the problems it describes. On the contrary, the bulletin fails to make a positive selection of various alternatives. Although the bulletin claims to describe current practice in the arrangement of operating suites, it would be advantageous if a more definite, critical and preferential view with regard to various layouts were expressed. This also applies to those chapters which deal with the engineering services required in those buildings. An engineer, if instructed to provide any of the various services, would find none of his problems answered by this bulletin. Curiously, the first chapter describes all the points which will not be discussed in the bulletin.

From the medical point of view, the bulletin contains a great deal on which a number of surgeons questioned by the reviewer had divided views, but they all agreed that a suggested floor area of 360 sq. ft. for an operating theatre was small. Also, with regard to recovery rooms, the suggestion that patients may be left on a trolley to recover is a very dangerous one, as there is no assurance that they would remain on it despite the rigid hospital regulations that no patient should be left alone until he has fully recovered consciousness. A workshop for the operating technician would be a welcome addition to the proposed layouts of operating suites.

The Ministry has promised the issue of further bulletins dealing with such problems as accommodation for nursing staff, consultative outpatient departments, etc. Apart from these aspects there appears to be one important part of the Service which one might claim to be deserving of some attention in the future. In recent years great advances have been made in various branches of surgery, and especially in the field of orthopaedics, where the replacement or repair of various parts of the skeleton by the use of metallic or plastics implants has been practised on a large scale. The majority of these new techniques have a good chance of being established as routine procedures. To accomplish this a more efficient and reliable system of co-operation and control should be developed between the surgeon, the Ministry, and the manufacturers of surgical appliances. The use of internal implants requires specialised bio-mechanical knowledge which the surgeon is not expected to have, and the manufacturers in this country are not in a position to offer. A bulletin dealing with these problems would be a most welcome addition to the promised series, especially as it may help, directly, the patient with whom the Service should be mainly concerned.



An understanding of the circulation of personnel, instruments and materials is an important factor in the functional planning of hospital operating suites. The main features are given in this diagram, taken from the first of the new Hospital Building Bulletins.

DAMS, SLUICES AND CHANNELS

Irrigation and Hydraulic Design. Vol. 2: Irrigation Works. By SERGE LELIAVSKY. *Chapman and Hall Limited, 37 Essex-street, London, W.C.2.* (294*s.*)

The first volume of Dr. Leliavsky's monumental work on irrigation was published in 1955 and contained the general principles of irrigation design dealing with percolation under structures, erosion behind structures and steady flow through channels. The present volume is concerned with the application of these principles to the specific design of irrigation works and irrigation planning.

The design and construction of an irrigation system presents the hydraulic engineer with many opportunities for exercising his art, five of which might be listed as follows: (i) The design and construction of the barrage which will pond up the river, with gates provided to allow negligible obstruction in high flood flow. Hydraulically this is a problem of the design of piers and abutments offering the minimum resistance to flow; structurally the problem is mainly one of the stability of the piers under the maximum head and the level and thickness and extent of the floor for distributing the loads and protection against piping and erosion. (ii) The construction of the head regulator giving access to the main canal; this may or may not be integral with the barrage. Usually, means are provided for excluding the coarsest part of the river sediment load and for ejecting some of the coarsest bed material from the head reach of the canal. (iii) The design of off-takes to the secondary branches and intermediate regulators which allow the water levels to be maintained in periods of low flow. (iv) The design of smaller distributaries and outlets which pass irrigation water to the cultivators, who thereafter assume responsibility for its distribution through water courses to the fields. (v) The necessity for adequate drainage to prevent waterlogging and, in very flat areas, the installation of pumping stations to lift the drainage water back into the rivers or the sea.

The design of the channels is also a matter calling for considerable experience and skill. It is now generally recognised that the dimensions of a silt-stable channel and its slope are uniquely dependent on the discharge and the solids transported by the water, but the relationships between these quantities have not yet been finally established. Whereas in India, for example, it is usual to base design on the constancy of the Lacey silt factor $f = 0{\cdot}75\sqrt{R}$ (V being the velocity and R the hydraulic radius), in Egypt the channel dimensions are given as functions of the slope. Lately, however, for the smaller discharges in the distributaries, these functions have been replaced by a simpler formula in which the velocity is linearly dependent on the depth. The recent work of Inglis, in which the solid transport is introduced into the equations for the dimensions, is a step forward but their form has not yet been experimentally verified. Many of these topics are dealt with in Leliavsky's book which includes also discussions relating to such subjects as cross-drainage syphons, weirs and measuring flumes, canal bridges, aqueducts and gates. Engineers will particularly welcome the detailed analyses of various types of these constructions drawn from existing works and mainly falling

within the author's personal experience while directing irrigation work in Egypt.

It is clear that the main problem now facing engineers in Egypt is that of waterlogging, due to the too liberal application by cultivators who had for many years been starved of water. Possibly the more rational use of water based on the work which has been done on soil-moisture/plant relationships as well as the Government measures already taken to lower to below ground level the water levels in the distributaries will, in time, redress the balance.

It is the author's intention to supply the irrigation and hydraulic designer with all the information, data, figures and tables which may be needed to perform his professional duties, not excluding some 200 pages on bridge design. In this he has succeeded, though the struggle to be comprehensive—the book costs 14 guineas—has contributed to a certain raggedness in the treatment which is not quite masked by the author's lucid and conversational style. Many references are given and a subject index of novel form provided which should enable the material to be readily accessible to the reader requiring information on some specific point.

NEW BOOKS

Applied Building Construction: A First Year Course. By A. MEDLYCOTT. *Chapman and Hall Limited, 37 Essex-street, London, W.C.2.* (25*s.*)

A number of persons, all experts in their own sphere, seeing a brick wall in the course of construction, might each be interested in different aspects of the building: the bricklayer in the bond, the structural engineer in the stresses, the architect in the subtle balance of solid and void, the scientist in the thermal insulation, and so on. This book aims at a target centrally placed between these various aspects of building and, in so doing, incorporates all of them to some extent. It covers a little more than is set out in the average syllabus for first-year students. The numerous sketches are of the architect's "tablecloth" variety; each of them consisting of some small detail of a building and it is left to the student to fit them together into working drawings.

Directory of Opportunities for Graduates, 1958. Edited by CLIVE LABOVITCH. *Cornmarket Press Limited, 1 Lower James-street, London, W.1.* (8*s.* 6*d.*)

Details are provided in the reference section of this publication to more than 220 organisations in all sections of industry, including Government departments and the nationalised industries, which recruit university graduates. There is much information about the types of graduates required, the training given by the body concerned, the location of employment, and salaries and pensions. Other particulars refer to the activities of each of the organisations and the addresses to which inquiries respecting employment should be sent. The editorial section contains a series of articles on conditions in industry generally. Copies are distributed gratis to all final-year students at universities in the United Kingdom.

Technical Reports of the Electrical Research Association. *Thorncroft Manor, Dorking-road, Leatherhead, Surrey.*

"The Testing of Wind-Driven Generators Operating in Parallel with a Network," by D. E. Villers, C/T116 (18*s.*); "Synthetic Resin Cements for Glass-to-Metal Seals for Use in Flameproof Enclosures," by H. F. Church, D/T102 (6*s.*); "The Variables that Arise in Contactor Testing," by H. W. Baxter and Z. Cetnarowicz, G/T306 (12*s.* 6*d.*); "A Simple and Inexpensive Emission Regulator for Ionisation Gauges," by M. P. Reece, G/XT160 (4*s.* 6*d.*); "Reverse Driving of Short Arcs," by A. E. Robson, L/T341 (6*s.*); "Some Magnetic Properties of Dilute Anisotropic Ferromagnetic Alloys," by W. Sucksmith, N/T74 (6*s.*).

Annuaire de L'Équipment des Industries Mécaniques, 1957-1958. By M. COYAUD. *Dunod, 92 Rue Bonaparte, Paris (6e), France.* (200 francs.)

This directory of mechanical engineering equipment (for foundries, workshops, etc.) is made up of an alphabetical list of French manufacturers and importers, together with a classified list of their products. As appendices there are lists of trade marks and trade names, and of foreign manufacturers represented in France, arranged geographically. The fact that the index to products is given in French only is something of a drawback, although there are outlines of the classification in French, English, Spanish and German at the beginning of each major section.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Power Hammers. B. AND S. MASSEY, LTD., Openshaw, Manchester, 11. Self-contained pneumatic power hammers, from 1 to 10 cwt. capacity, with slides for guiding the tup. Details of foundations and of special variations from standard design are given, together with examples of work done. Illustrated brochure.

Vertical-Chucking Lathe. CHARLES CHURCHILL AND CO. LTD., Coventry-road, Birmingham, 25. "Vertimax" production lathe, a vertical-spindle chucking machine with two tool slides, each with hydraulic feed. The machine is built in three sizes, and full details of each are given, together with tooling capacity charts, in this illustrated brochure.

Photographic Contact Materials. E. N. MASON & SONS LTD., Colchester. "Criterion" materials for photo-copying by the contact process. Booklet describes various methods and their advantages; detection of common faults and preparation of drawings

Metal Products. METAL INDUSTRIES LIMITED, Universal House, 60 Buckingham Palace-road, London, S.W.1. Descriptive notes and principal products of the ten members of the Metal Industries group. Illustrated brochure entitled *Who we are, what we do.*

Oil Mist Coolant. STANLEY JEVONS TOOL CO., Avon-street, Birmingham, 11. Coolant spraying nozzle, complete with ½ gallon coolant tank, fluid piping and air hose, ready for connecting to any air supply of 50 to 150 lb. per sq. in. pressure. Illustrated leaflet.

Bar Turning. FRANK WHITELEGG LTD., 304 High-street, Sutton, Surrey. Machines for bar turning made by Th. Calow & Co., Bielefeld, Germany. Tungsten-carbide and high-speed steel tool models are included, and the size ranges are from 15 to 150 mm. (½ in. to 6 in.). Three illustrated leaflets.

Flourescent Lamps. THE ILLUMINATING ENGINEERING PUBLISHING CO. LTD., 32 Victoria-street, London, S.W.1. Guide to use of fluorescent lamps is included in the December (1957) issue of "Light and Lighting." (3*s.*)

Steam Trap. DRAYTON REGULATOR AND INSTRUMENT CO. LTD., West Drayton, Middlesex. Choice, installation, operation and maintenance of Drayton-Armstrong steam traps with lists of sizes and capacities. Illustrated brochure.

Electrical Precipitators. W. C. HOLMES & CO. LTD., Turnbridge, Huddersfield. Holmes-Elex electrical precipitators for all types of dust extraction. Washing or automatic rapping of plates. Sizes and operating conditions are given in publication 69.

Feedwater Control. JAMES GORDON & CO. LTD., Dalston-gardens, Stanmore, Middlesex. Two- and three-element controls for maintaining boiler feed water supplies. Arrangements and items given in leaflet No. 113.

Dust Filtration. POWER-GAS CORPORATION LTD., Stockton-on-Tees. "Favorit" filter process for the recovery of dust and fumes from industrial processes. List of standard sizes and diagrams of arrangements. Leaflet.

Cement. LAFARGE ALUMINOUS CEMENT CO. LTD., 73 Brook-street, London, W.1. Ciment Fondu, a cement with the combined characteristics of being rapid hardening, corrosion-resistant, a refractory, and a good insulator; particularly suitable for maintenance work. "The Cement for Industry," a 32-page booklet. This paragraph amends an entry published in this column for February 14.

On the Shelf

By Frank H. Smith

The American Society of Mechanical Engineers produces a glossy Annual Report which it issues as Section Two of *Mechanical Engineering*.

That covering the year ending September 30, 1957, gives a foretaste of the projected "United Engineering Center" to replace the present Engineering Societies' Building at 29 West 39th-street. It will be near the U.N. headquarters.

What, however, caught my eye was the A.S.M.E. vital statistics. In one year, the Society had 315 meetings with a total of 859 papers and it published 707 preprints. The membership of the A.S.M.E. is 52,012—a figure that is boggle-worthy by most British standards. Funnily enough, in a cursory glance through the Report I failed to see any reference to a Library. And by the way, *Mechanical Engineering* has caught the fever and suffered a cover-change. It has also made other changes in the text-matter—a result of advice taken from the Eastman Research Organisation, "a leading editorial research agency" which, it seems, analysed "the reading patterns of A.S.M.E. members."

An interesting paper entitled "The Geometry of the Job" appears in the *Transactions of the Institution of Engineers and Shipbuilders in Scotland*, volume 101, part 2. The author, W. Heigh, "demonstrates some typical arithmetical and geometrical devices, including approximations, short cuts, charts and scales by means of which time can be saved at all stages of design and manufacture." The paper aims at design and drawing offices, pattern shops, mould lofts and surface tables.

I am a little puzzled by a leaflet received from the American Institute of Industrial Engineers, Inc., 145 North High-street, Columbus 15, Ohio. It says that their Research Information Committee is starting "to secure abstracts of research performed in the period July 1, 1952, to July 1, 1957." Sources from which information will be solicited are universities, industrial organisations, research institutions, etc. The information collecting programme will provide a valuable service to industry and universities and especially to industrial engineers. They hope to collect research abstracts (what *is* a research abstract?) in work measurement, methods, plant engineering, human engineering, engineering economics, organisation planning, industrial statistics, production control, data processing, operations research and cost analysis. If anybody has any research abstracts lying about he should send them to Research Information Committee, A.I.I.E., Department of Industrial Engineering, Washington University, St. Louis 5, Mo.

An 80-page catalog (*sic*) has arrived from Interscience's New York house. It is conveniently subject-divided and has subject and author indexes.

A good 75 cents worth is the *Review* of the National Research Council (Canada) for 1957. It reviews the Council's activities for 1956, and is comparable with, but probably wider in application than, our own National Physical Laboratory. The work of the Science Laboratories, the Engineering Laboratories and Associate Committees are covered in the 289 pages and the range of research will, I think, surprise even those who are aware of the Council activities in their own particular field. Anybody who is interested should apply to the Public Relations Office of the N.R.C. at Ottawa.

Bulletin No. 1 of the New South Wales University of Technology (April, 1957, but only just received) is "A bibliographical survey of hydraulic analogies" by R. A. A. Bryant. This is in chronological order and stretches from 1911 to 1956 with 100 references. The bibliography traces the development of research into the similarity of flow of water in a shallow channel and the high speed flow of a gas. The address is Box 1, Post Office, Kensington, New South Wales

Research and Development

IT PROJECTS AS IT PHOTOGRAPHS AS IT DEVELOPS

A film gate having three adjacent apertures is a notable feature of a new equipment for presenting and recording information on cathode ray tube displays rapidly. 35 mm. film is drawn frame by frame through the gate and as one frame is exposed to a cathode ray tube its predecessor is developed and the latter's predecessor is being projected. The processing cycle can take as little as 6 seconds, and the film is said to keep indefinitely. The equipment is being used for air-traffic-control radar problems.

Designed initially in conjunction with the Ministry of Supply, the equipment has been in full-scale production by Kelvin and Hughes Limited, Basingstoke, Hampshire, for some time. It is now being sold in quantity to the United States.

Self contained and automatic, the rapid processing photographic projector takes 1,000 ft. reels of film which, at a normal film speed of four exposures per minute, gives a continuous operating period of about 24 hours. Integral reservoirs permit the replenishment of chemicals without stopping the machine. The extremely short processing cycle makes severe demands on the films, and processing solutions, and special types have been developed by Ilford Limited.

The film gate consists of a light-tight sandwich in the lower half of which there are three adjacent apertures. The film is held in accurate registration over the apertures by means of a solenoid-operated clamp which, in addition to clamping the film throughout the three operations, crimps each frame on to the film gate to prevent light from the projector travelling internally along the film and fogging it at the camera and processing stages.

At the camera aperture the film is exposed through an anastigmat lens and drum shutter to the display on the face of the cathode ray tube. At the processing aperture the exposed film is subjected to a spray of processing chemicals from three venturi jets. Each chemical is applied individually to prevent the inter-mixing of the developer, fix and bleach. The air feed is preheated to raise the temperature of the spray at the film and to facilitate drying by means of a single, central air jet.

At the projection aperture the film record is projected by means of a high-quality projection lens illuminated by a compact source mercury-xenon arc lamp. Illumination on a 5 ft. diameter screen is about 100 candles per sq. ft.

For negative processing, the operational cycle time is 6 seconds; for positive processing it is 12 seconds. The times can be shortened, but with a loss of contrast and permanence. During tests, in which a lined card was substituted for the cathode ray tube, positive and negative presentations were obtained which clearly resolved 1,400 lines across the picture at f/2 and 2,000 lines (that is, 1,000 black and 1,000 white) at f/4, as viewed on the projected picture.

When the equipment is in operation the sequence of process timing and synchronisation with, for example, a radar scanner is determined by an arrangement of nylon cams driven via an induction motor in conjunction with a magslip and servo-amplifier system. In the first stage, the solenoid-operated camera shutter closes and the film clamps lift, allowing the film to be drawn through the gate.

Film is drawn from a cassette by a sprocket at uniform speed and fed into a light-proof chamber in front of the film gate. A spring-loaded sprocket, situated in the feed chamber, maintains the film at the correct tension and permits a free loop to build up between it and the feed sprocket during the exposure period. The tension so imposed facilitates accurate sprocket registration and precise longitudinal registration in the film gate to an accuracy of $\pm 0{\cdot}0015$ in. Lateral registration of the film is ensured by agate-faced pads and spring-loaded stainless steel rollers located in the lower half of the gate. A transport sprocket, situated on the outfeed end of the film gate, rotates by intermittent 90 deg. movements and transports the film through a distance of 10 perforations while the camera shutter is closed.

Normally the projectors are operated in pairs, so that a continuous display is assured, optical registration of the projectors being achieved by means of a double-sided mirror, common to both equipments.

A fog level of 0·05 or less is obtained for positives or negatives. A maximum density of up to 2·5 is obtainable for a negative in a 15 second cycle. A projection density of 1·5 may be obtained for the positive process.

REFRIGERATED BAFFLES FOR DIFFUSION PUMPS

High vacuum diffusion pumps find application in nuclear particle accelerators. The importance of maintaining an optically clean vacuum system in such machines is of great importance. Because of this, many intricate forms of baffles have been used to prevent the pump-operating fluid from contaminating the system.

Edwards High Vacuum Limited, Crawley, Sussex, have devised some baffles for this purpose. They consist of a series of chevron-shaped baffle plates cooled to sub-zero temperatures by means of a refrigerant. The illustration shows one of the baffles complete with mechanical refrigerator. The model shown is suitable for mounting above the company's 24 in. fractionating oil diffusion pump, which has an unbaffled pumping speed of 12,000 litres per second and can attain a final vacuum of 5×10^{-7} mm. Hg. Other size baffles are available and for work on particle accelerators the company have designed a series of butterfly valves and gate valves for control purposes. The complete unit is designed to occupy a minimum depth.

AT THE BASE OF THE MAGNETIC RECORDING

In any data-processing system, recording plays an important part. The type of recording used and the amount of time that the record is held vary extensively; but, in many applications using computers, magnetic tape provides a convenient medium for the record. Whatever the method used in an application of tape for data recording, the aim is to reproduce faithfully the number of pulses in the signal to be recorded, and also to keep the correct time sequence.

The most common fault occurring in the magnetic recording of pulses is one that involves momentary separation of the tape and recording head. This gives a loss of amplitude of the reproducing signal. In data recording, however, it is only necessary to know whether a pulse is present or absent, and reduction in amplitude can be tolerated provided that the pulses can be distinguished absolutely from the electrical noise in the system. When the signal amplitude falls below this limit, faulty reproduction of the signal occurs. This is called " drop-out."

An investigation into the occurrence of drop-out is contained in a paper " Magnetic Tape for Data Recording," by Dr. C. D. Mee. The paper is to be published in volume 105, part B, of the *Proceedings* of the Institution of Electrical Engineers. In one section an experimental test apparatus for detecting drop-out is described. The technique of examining signals recorded on tape by making the recording visible with colloidal magnetite is also outlined.

The recording system having the widest application is the one in which portions of a thin film of magnetic oxide are saturated in the longitudinal direction of the tape; some form of plastics material is usually used as a base for the film. The direction of magnetisation changes through 180 deg. in accordance with the directional changes in the field generated in the gap of a magnetic recording head. The changes in the field generated by the head are usually rapid, and the spread of the transition region on the tape is fixed largely by the dimensions of the recording head gap, the magnetic characteristics of the tape, and the separation between the head and the tape. In conventional systems, up to 400 reversals of magnetisation per inch are used. Such a recording will thus consist of 400 magnets per inch, alternately magnetised to maximum remanent induction, separated by transition regions where the magnetisation changes rapidly. This system of recording is called " non-return to zero " (n.r.z.). An alternative system is that called " return to zero " (r.t.z.), in which the recording tape is unmagnetised in regions between the recording pulses: the recording consists of pulses of either positive or negative magnetizing fields, which are short in duration compared with the repetition period.

It is possible to design equipment that will test both n.r.z. and r.t.z. tape recordings, and the author describes the design and circuit arrangements of a drop-out tester. An examination of drop-out occurring on samples of commercially available tapes showed that, provided sufficient

care had been given to the production of a uniform magnetic lacquer with no foreign particles and provided the tape had been made under dust-free conditions, those having cellulose-acetate or polyester bases were superior to others. Polyvinyl-chloride bases of Continental manufacture are used extensively for audio recording tapes in Britain but, in general, the quality is poor for data-recording tape bases, owing to the high incidence of local thickness changes. "Small batches of high-quality p.v.c. have proved to be excellent as base material," comments the author, "but such quality is available only in sample lengths. Cellulose-acetate and, more recently, polyester are used at present for data-recording tape bases. Both materials are manufactured with a high degree of uniformity and with virtual freedom from surface blemishes. The inherently low susceptibility of polyester to moisture absorption and its resistance to tearing have made it more favourable for data-recording tape."

All the tapes that were tested in the investigation had similar magnetic qualities and consisted of acidular particles of γFe_2O_3 embedded in a flexible binder suited to the various base materials. The particles were about 1 micron long and had a length-width ratio between 5 : 1 and 10 : 1. Drop-out tests were performed on 0·5 in. wide cellulose-acetate based tapes and polyester tapes, using a pulse density of 200 per in. per track. Eight tracks were tested at a drop-out level of 8 dB. Tapes made of cellulose-acetate of British manufacture had an average length of about 400 ft. between drop-outs; for American acetate this length was 700 ft. and for recent polyester 1,100 ft.

The figures quoted refer to magnetic layers that had been manufactured under similar conditions. Thus they reflect to some extent the quality of the base material. Examination of some American tapes, which were claimed to be manufactured for data recording, showed that nearly all the drop-outs were due to faults that momentarily lifted the tape from the recording or reproducing head. At the recorded pulse density of 200 per in. and a drop-out level of 6 dB, about half the detected drop-outs were caused by removable defects, such as chips of base material. These were either not cleaned off during the slitting process or were shaved off by the guides of the tape deck. Most of the permanent faults were also due to base defects, such as dents or small air bubbles. Dr. Mee remarks that "Clearly, in this case, the tape manufacturer cannot further improve his product apart from exercising caution with regard to foreign particles. Future progress depends more on the availability of flaw-free base material and improved systems for handling the tape." In the latter case it seems that systems in which the film does not come in contact with the head might be used with advantage. A description of a two-head non-contact system is included in the paper.

SEE CRYSTALS FORMING

An icebox used to study the formation of dendritic crystals will be exhibited at the Brussels World's Fair by the United States. The machine, which takes five minutes to make crystals 2 to 4 in. across, is a product of the division of engineering and applied physics at Harvard University.

Water in the tank of the machine is supercooled and then seeded by a tube cooled to a very low temperature at the appropriate time. At this point, long dendritic crystals begin to form in the water. They are viewed by polarised light that shines through the tank from the back; a second layer of polarising material between the crystals and the observer causes the crystals to appear coloured. The hue depends on the thickness of the ice, the inclination of the light and the crystal, and the position of the two polarising screens. The usefulness of the icebox as a research tool lies in the similarity of its dendritic crystals to those formed when supercooled metal in a casting solidifies.

Design

CALCULATION OF STRESSES IN RAILS DUE TO STATIC VERTICAL LOADS

*By C. Storey**

A survey of the literature on the calculation of the deflections and bending moments in rails shows a broad division between solutions involving a continuous elastic support and solutions involving equally spaced elastic point supports. This article is concerned with briefly reviewing these various methods and comparing their merits.

Continuous Foundation.—Assuming a continuous linear elastic foundation, a simple analytic solution is possible[1] and a discussion of the effects of variables such as moment of inertia I, support spacing l and modulus of foundation k (load per unit length of rail necessary to cause unit deflection in the foundation) can be given directly without calculation. The analysis is easily extended to dynamic conditions, such as moving pulsating loads, to represent the out-of-balance weights of a locomotive. The method is limited, however, because of the assumption of a continuous foundation and by the fact that the bending equation no longer holds when the rail lifts from the horizontal. Extended tables of the functions necessary for calculation of deflection and bending moment by this method are given in a fuller paper by the author which is referred to in the last paragraph of this article.

* Of the Research Department, British Transport Commission, Derby.

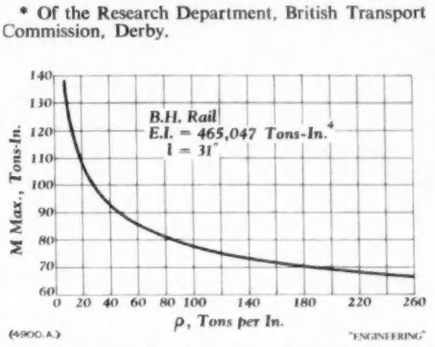


Fig. 1 Variation in the maximum bending moment due to a changing foundation modulus. The curve relates to a B.H. rail (EI = 465,047 tons-in.) and supported at 31 in. centres.

Spaced Supports.—When equally spaced linear-elastic point supports are assumed, the problem is more complex and has been solved in a variety of ways. Dekker[2] used the three-moment theorem to obtain an elegant approximate solution in terms of continuous functions which could be simplified for certain positions of the load. Following this, Desprets[3] gave another solution using the three-moment theorem but without making any approximations. This method was revived by Gough[4] who applied it to rail joints and "slack" supports. A further interesting method of solution was that of Czitary[5] who used the integral approximation to an infinite determinant to solve the set of simultaneous equations obtained by applying the three-moment equation to successive spans. Much of the labour of Desprets' approach has been removed in a recent paper by the present writer[6] and a number of applications are given there to illustrate the simplified method. For example, Fig. 1 shows the dependence of the bending moment under a load at mid-span on the foundation modulus ρ (this is the load necessary to cause unit deflection of a support, and $\rho = k\,l$). Similarly, the dependence of this bending moment on support spacing and moment of inertia has been investigated. It is shown that over the practical ranges of variation of these variables, ρ has much more effect on the bending moment than the other two. As another example, Fig. 2 shows

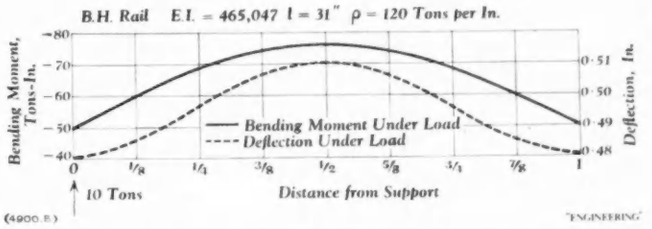


Fig. 2 Influence line for a point load. The rail characteristics are those of Fig. 1 and the foundation modulus is assumed to be 120 tons per in.

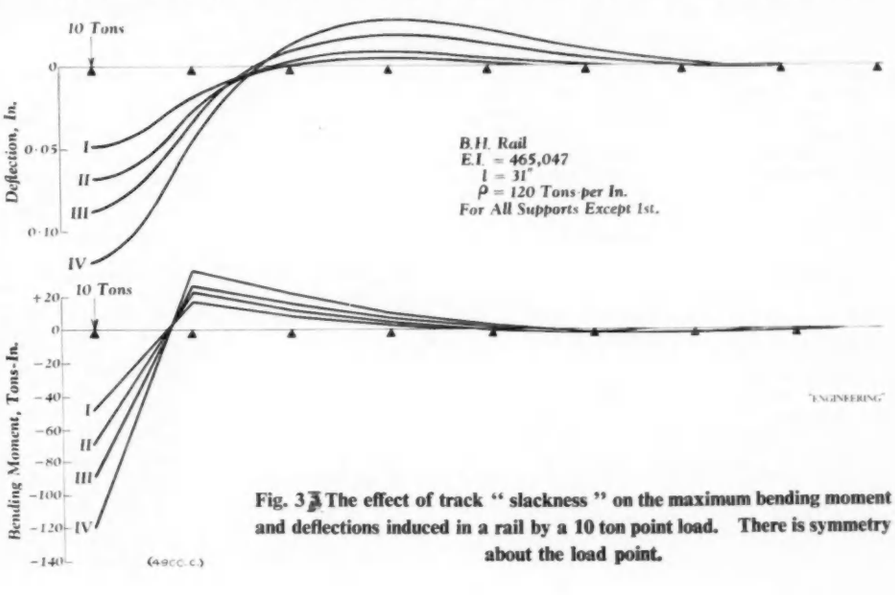


Fig. 3 The effect of track "slackness" on the maximum bending moment and deflections induced in a rail by a 10 ton point load. There is symmetry about the load point.

Continuing **Design**

influence lines for deflection and bending moment as a load traverses a span.

When the technique given in Reference 6 is used, computations are reduced to a minimum and are quite straightforward for any position of a load in a span. The method, however, still breaks down when the rail lifts from the horizontal.

A more direct method of solution is to use the relaxation process to solve the two sets of simultaneous equations which arise when the bending equation is integrated in terms of the deflections and slopes at adjacent supports. Since the rail is infinite, the sets of equations are infinite; but, proceeding outwards from the load, the deflections and bending moments fall off quite rapidly, so that the number of equations it is necessary to solve is limited. In practice, relaxation need only be continued until the residuals fall below an arbitrarily assigned level.

The main asset of the relaxation method is its extreme flexibility since, with only slight modification it can be adapted to widely different conditions. (In general only the operation table need be changed.) The lifting of the rail from the horizontal is treated correctly by using different operation tables for negative and positive deflections, the foundation modulus being taken as zero when the rail lifts. As an example, Fig. 3 shows deflections and bending moments for a load over a sleeper having various degrees of "slackness." In this diagram all supports except the first have a foundation modulus of 120 tons per in.; in curve I the modulus is also 120 tons per in., in curve II it is 60 tons per in., in III it is 30 tons per in. and finally in IV it is zero. A marked increase in deflection and bending moment is apparent, and there is an even greater change in the maximum range of bending moment.

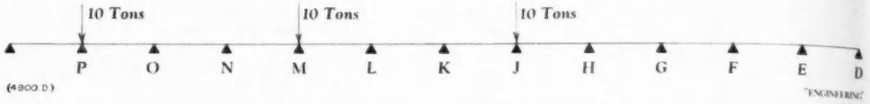
The question of voids is treated in detail, distinction being made between localised and extensive voids. Examples of semi-infinite beams with end fixing moments to simulate rail joints are given, and the problem of a continuous rail which has been jacked up by various amounts is treated.

Unfortunately each problem has to be considered separately, and the calculations are long and tedious compared with those of the other methods.

Comparison of Methods.—It is to be expected that the greatest divergence will be between the continuous foundation method and the spaced

ρ = 120 tons per in. = 31 in.

Support	Deflection, *in.*			Bending moment, *tons-in.*		
	Three moment	Continuous bed	Relaxation	Three moment	Continuous bed	Relaxation
M	+0·0401	+0·0398	+0·0400	−53·3	−67·6	−54·2
L	+0·0216	+0·0220	+0·0227	+27·2	+21·6	+27·9
K	+0·0225	+0·0229	+0·0235	+27·3	+22·0	+28·0
J	+0·0419	+0·0417	+0·0420	−56·0	−70·9	−57·0
H	+0·0198	+0·0200	+0·0207	+14·8	+ 9·1	+14·6
G	+0·0017	+0·0019	+0·0020	+11·9	+12·0	+11·8
F	−0·0017	−0·0019	−0·0027	+ 2·5	+ 3·2	+ 4·3
E	−0·0008	−0·0009	−0·0014	− 0·6	− 0·4	− 0·1
D	−0·0001	−0·0001	+0·0003	− 0·5	− 0·5	− 1·1



methods. A numerical investigation shows that this divergence increases as the stiffness of the foundation increases. For ρ = 120 tons per in., which is assumed to be about average for track in this country, the difference is about 10 per cent. for maximum bending moment and about 1 per cent. for maximum deflection. The accompanying table gives a comparison of the three methods for a typical problem with three equally spaced 10 ton loads. Because of symmetry, only half the solution need be given.

A study of this and similar tables for other values of the foundation modulus and other positions of loading shows that the difference between the relaxation method and the three-moment method becomes more marked on moving away from the loads and the effect of assuming a negative reaction in the latter case is made apparent. On the other hand, the continuous foundation and three-moment methods give close agreement well away from any load. In general, the results for a continuous foundation are seen to lie between those on supports and between supports by the spaced methods. Only the relaxation method takes account of the weight of the rail and supports, but, since the value of EI is so large, this is a minor effect.

So far as deflections are concerned the results given by the three methods differ so little that ease and convenience of computation become the deciding factors. This cannot be said for the bending moments, since the divergences are larger, but conclusion as to whether the spaced method or the continuous method comes nearer to the actual track conditions must be left to a comparison of theory and experiment. Intuitively it seems that the spaced methods more closely represent physical reality and they do discriminate between loads on supports and loads between supports. It is interesting to note, however, that the American Rail Track Stress Committee[7] claimed that the continuous foundation method adequately represented their experimental results.

The above article is a summary of a very much longer paper in which mathematical details of the three major methods are discussed and many more numerical examples given. The paper includes a brief historical outline of the subject and a bibliography of 30 books and other publications.

Photocopies of the full paper are available from the Publisher, ENGINEERING, 36 *Bedford-street, Strand, London, W.C.2. Price* 10*s. each, post free.*

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[5] E. Czitary, *Org. f.d. Fortschritte d. Eisenbahnwesens*, vol. 91 (1936).
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Acknowledgments.—The author wishes to thank Mr. T. M. Herbert, Director of Research, British Railways, for permission to publish this article. Thanks are also due to previous mathematicians of the Research Department, and to Dr. H. I. Andrews who initiated the relaxation solution of the problem.

WEB BUCKLING AND PLATE GIRDER DESIGN

The tendency to use plate girders of larger spans —more than 200 ft.—with the consequent increase in their depth, has brought into prominence the dearth of available knowledge concerning the buckling conditions in such girders. In a paper read before the Institution of Structural Engineers on February 13, Dr. K. C. Rockey dealt with the buckling of web plates and the stiffening required under various conditions of loading. Much of the paper consisted of an account of the experimental work carried out by Dr. Rockey and his colleagues at University College, Swansea, and the results of their investigations.

In the early part of the paper, the buckling of webs under pure shear was considered both for panels with vertical stiffeners only and for those which have horizontal stiffeners also. An interesting point which arose from the experimental work was that the stiffness coefficient, K, of any panel appears to have a "ceiling" value which is reached for a certain value of the stiffness ratio, but any further increase in the latter does not affect the value of K appreciably. The behaviour of panels under bending was considered and the results of loading tests compared with those of Dubas, Massonnet and other authorities. The question of combined loading was also treated in another section of the paper and interaction curves plotted for each sub-panel.

In considering the shear buckling of a panel, it was noted that the critical buckling load may be exceeded without causing collapse of the panel owing to the development of diagonal membrane stresses, also that the lateral deflection may be small compared with the thickness (though the question of initial eccentricity must be taken into account). This was described in the section of the paper devoted to the post-buckled behaviour of the web itself, in which the ratios of deflection/thickness, area ratio for stiffeners and ratio W/W_{cr} were plotted. For panels subject to bending, K was plotted against stiffness and the deflection/thickness ratio against stiffness ratio for single and double-sided stiffeners. The effect of flange rigidity on web buckling was shown graphically (but has been fully dealt with in the author's "Plate Girder Design," in ENGINEERING, page 788, vol. 184, 1957).

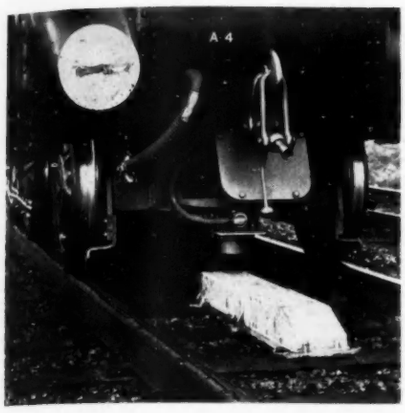
The effect of bending on webs is less important than that of shear and for this reason that part of the paper was devoted to a discussion of the optimum position and stiffness ratio for stiffeners and a tentative design curve for the latter.

The final section of the paper (on design) emphasised the fact that web buckling does not cause collapse and that loads up to 50 per cent. in excess of the critical value do not produce buckles large enough to be readily noticeable. In addition, the author called attention to the difference between riveted and welded structures; in particular, the clamping effect of riveted flanges and the factor of safety for welded webs subject to shear plus direct compression (a point overlooked in some specifications). This section dealt with both light alloy and steel girders and, for the former, the curves showing the influence of horizontal stiffeners on buckling were most interesting. The author recommended certain rules for (presumably) riveted vertical stiffeners and for horizontal stiffeners in pure bending, but did not deal with the question of combined loading or that of stiffeners subject to direct load or moment.

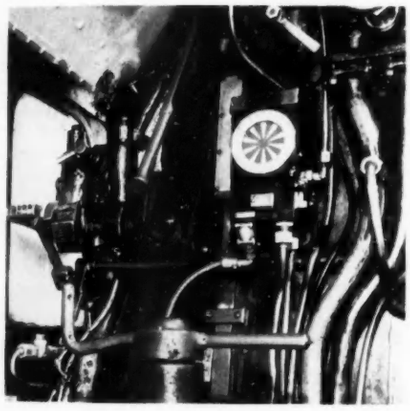
Many of the author's recommendations are acceptable quite generally. On the other hand, the value of the paper would have been enhanced by some comparison with other specifications, e.g., B.S. 153 Draft or the German DIN 4114, particularly with regard to stiffness ratios for stiffeners. In the discussion which followed Dr. Rockey's paper, several speakers expressed the view that clarification on this matter would be valuable to the design engineer.

DETAIL DESIGN FOR DEPENDABILITY IN SERVICE

Development of Automatic Train Control Completed



Locomotive receiver about to pass track inductors, showing cable connector leading to main wiring.



Control unit in cab with reminder indicator, which must be showing before cancellation of the warning can become effective.

The British Transport Commission announced recently the placing of orders valued at about £500,000 for the first stages in the installation of its inductive warning type of automatic train control. This, after extensive trials between New Barnet and Huntingdon and throughout up and down main lines between London and Grantham, has received the sanction of the Minister of Transport and Civil Aviation for general use.

The apparatus so approved has been designed for steam locomotives fitted with the vacuum brake, but adaptations for other forms of motive power and for air brakes are being arranged, the general principle of operation remaining unchanged. This is practically the same as that seen in the equipment due to the late Mr. A. E. Hudd and adopted by the former London Midland and Scottish Railway for its Southend line. On the track at the approach to each distant—now also each multiple-aspect—signal is a permanent magnet which sets the locomotive apparatus in action. If nothing else occurs within 1 second, a horn will sound and within 3 seconds a gradual brake application will be initiated. The driver can, however, by actuating an acknowledging handle stop this action, but this brings a conspicuous indicator into view, to remind him of what he has done, which remains showing until the next signalling location is reached. If, however, the distant signal is " off " —or the multiple-aspect signal showing green—an electro-magnet, located immediately beyond the permanent one, will be energised and the engine apparatus reset before any warning action can begin. A relay assembly is then operated to give a 2 second ring on a bell. (On the Southend line this signal is a short blast on a horn.)

The equipment has been specially designed to meet the arduous conditions of vibration, shock, heat, smoke, steam and extremes of weather met with on steam locomotives, the aim being that all components, battery excepted, shall function without shed maintenance from one shopping date to the next, but that should one fail it can be replaced without disturbing any wiring.

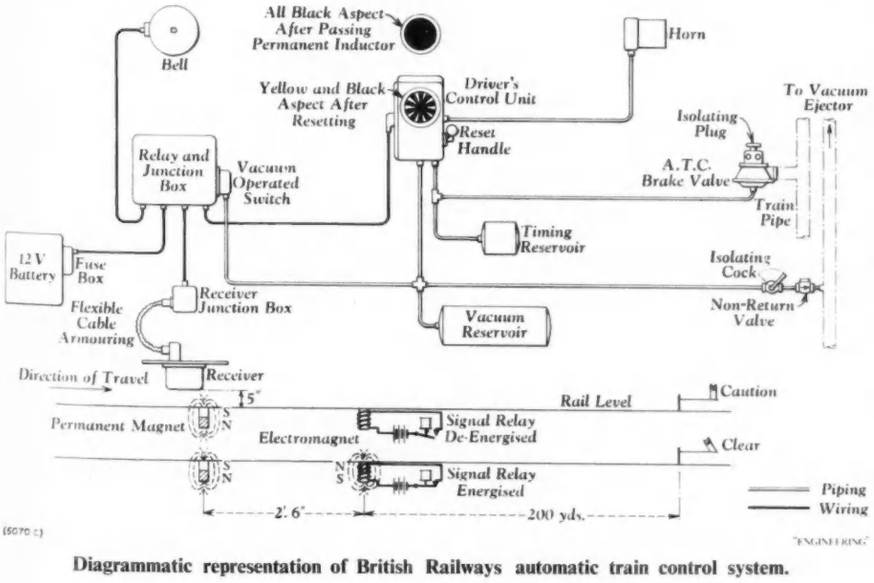
The permanent magnet, of Alcomax II and providing a flux able to act on the locomotive receiver up to at least 150 m.p.h., is 5 in. high and about 9 sq. in. cross-section, with spreader plates; the electro-magnet is larger, of Swedish iron, with windings arranged for 12 or 24 volt energisation at 9 watts. Both units have aluminium alloy casings for attaching to any type of sleeper and stand flush with new rail level. A ramp protects against dragging equipment. The windings are impregnated to a very rigid specification, with hermetically sealed connections to a terminal box, and are immersed in petrolatum, although tests are being conducted to ascertain if that is essential. A relay, the correct working of which is continually proved, controls the energisation of the windings.

The fields radiated by these inductors, which are of opposite polarity, are picked up by a receiver passing 5 in. above them. In this is a permanent magnet armature carried in nylon-loaded bakelite, itself forming a bearing for stainless steel trunnions. The adjustable stops have left-hand thread on the pins themselves, with right-hand locknuts top and bottom, as special precaution against moving under vibration. Flexible beryllium copper strips at each end of the armature carry the contacts and it moves between laminated pole pieces—on one of which is a coil energised when the driver actuates the acknowledging handle—in contact with iron collector plates. The whole, including the lower plate, is in a non-magnetic cast-iron pot, hermetically sealed to the upper plate, with rubber anti-shock mountings. Rapid replacement is facilitated by a rubber protected cable with sealed plug at each end, fitting into sockets on the receiver and on a junction box.

Plugs and sockets are designed to keep out water under pressures met with up to 100 m.p.h. and maintain electrical contact under severe oscillation. Spring loaded plungers bear against fixed studs—found by experience to be superior to pins engaging with sockets—and the plug rims are screwed down against solid rubber to form a hermetic seal. The gland in the receiver top plate is formed of two halves in black bakelite to hold collars soldered to the stranded wires, themselves continuous, and the whole is rendered solid by jointing with Araldite, an ethoxy resin.

The control unit in the driver's cab has been given an attractive appearance by using plating and well finished enamelling to encourage him to treat it reasonably. The top is specially shaped to prevent oil cans, tea bottles, etc., being placed thereon. All parts are either non-ferrous or of stainless steel, except where unavoidable. The solenoid, which actuates a disc type semi-rotary valve, is of Swedish iron finished in heavy dull nickel plating, found less liable to flaking than other forms. Ordinary lubrication being impracticable for valves and spindles by reason of the long interval between servicings, and by their proximity to the boiler, molybdenum disulphide is used. Internal wires are of the Uni-Pren type, as developed for the Air Ministry, and those leading away from the unit are in P.C.P. sheathed multi-core rubber insulated cable, to meet temperature requirements. Stainless steel flexible tubing leads from a plug connector to conduit running to the relay junction box. The horn is of diaphragm type combined with a small capacity chamber and the bell, made very powerful, to sound above the high level of noise in engine cabs, is of the thruster pattern with rubber bellows sealing the hammer shaft against damp, etc.

To eliminate corrosion in screw threads all conduit is jointed by rubber hose secured by Jubilee clips. All wiring is taken to the relay junction box, those wires requiring to enter it going on from the terminals to fixed studs. The relay unit itself is cast integrally with the lid, again with plungers bearing on studs when the lid is bolted down. The assembly is then absolutely proof against a washing down hose. At the side is an economiser switch to prevent current being consumed when the locomotive is without vacuum. Relays are of modified Post



Diagrammatic representation of British Railways automatic train control system.

Continuing **Design**

Office 3,000 pattern, with an all-round strengthening frame and base for mounting and, with the condensers, etc., are carried on a flexibly mounted tray. In addition to the knife edge bearing each armature has a beryllium copper strip suspension piece. Except on one relay, where platinum is used for reasons of space, all contacts throughout the equipment are of fine silver heavy duty type, found preferable to any other. The 32 Ah battery is in a steel compartment, with fuse box bolted on, divided into two 5-cell crates, charged every four to five weeks.

The brake valve, of diaphragm type, is double chambered. The lower chamber connects with the vacuum supply through a small orifice and the valve in the driver's unit, and also with a timing reservoir. The upper communicates with the train pipe, the diaphragm being normally in balance, in which condition a valve coupled to it is held closed to atmosphere by a spring. When braking is initiated at a track location the assembly functions to produce a constant rate of drop in the train pipe vacuum, regardless of train length. Total destruction is effected—provided, of course, the driver does not actuate the acknowledging handle—for a light engine or train up to 12 coaches in 13 to 15 sec.

A non-return valve serves to maintain vacuum in the main reservoir for sounding the horn when the driver has destroyed train pipe vacuum by a brake application; its parts are contained in a quickly replaceable cartridge. To put the equipment out of use in unavoidable necessity a sealed isolating cock is turned to cut off the main reservoir and destroy vacuum therein and the brake valve secured by a sealed plug so that it cannot act to apply the brakes when the opening of the economiser valve contact de-energises the driver's control unit.

It is of interest to note that the principle of producing a warning indication by permanent, and a clear one by electro-, magnetism was used by W. S. Boult for his cab signalling in the 1890's, demonstrated at high speeds on the Great Northern Railway. The inventor was unable, however, to obtain magnets of the lasting quality and power essential for practical service. With magnets of the kind now available his experiments might have had a different outcome.

PRESSURE SEALING BY O-RINGS

By J. R. Fawcett, B.SC., A.M.I.MECH.E.*

Although first mentioned as long ago as 1853 by T. Kennedy in a paper before the Institution of Mechanical Engineers, it is only in the last 18 years that the toroidal-seal or O-ring has been seriously developed. During that time it has achieved a popularity as a pressure-sealing device which can only be described as phenomenal. It would certainly be difficult to find any other device which has " caught on " so quickly or universally. There are now at least 30 manufacturers of O-rings in the United States and about six firms in this country are able to offer a reasonably wide range of sizes and materials.

Although the patent on which the developments were based was taken out by N. A. Christiensen in 1933, intensive development of O-rings only started in America about 1940, and it was shortly after this date that the comparatively narrow-section ring made of synthetic rubber began to be incorporated to any extent in aircraft designs. One of the most difficult problems was to produce a synthetic rubber which would withstand the extremes of temperature encountered in aircraft and yet still remain effective. So rapid was progress—helped, of course, by the demand for military aircraft—that design had been almost stabilised by 1945. Little has been published about the rubber compounds, which are usually kept secret by manufacturers, but American sources say that Buna-N synthetic rubber gives the best results for difficult applications. Rings are also being made of silicone rubber for high-temperature work, and of natural rubber for use with fluids which do not attack it. Graphite-impregnated synthetic rubber seals are also being produced. Other materials which are used for special purposes are nylon and polytetrafluoroethylene (Fluon or Teflon). O-rings are usually produced by conventional moulding processes, semi-circular grooves being accurately machined in plate moulds. After moulding, the flash is carefully trimmed off to leave the correct cross-sectional diameter within the prescribed limits (± 0·003 in. to ± 0·006 in., depending on the size).

The O-ring is now generally housed in a rectangular cavity (Fig. 1), V and round grooves having been found inferior in practice. The effectiveness of the seal at low pressures depends on the initial squeeze which is given to the ring by making the cavity smaller in one direction than the ring cross section. It is essential, however, if the ring is to function properly, that the cavity be wide enough in the other direction to allow it to roll when the pressure is applied. Standard sizes of O-rings with bores from $\frac{1}{8}$ in. to $15\frac{1}{2}$ in. nominal, together with useful information on the sizes of grooves and the diameters of shafts and recesses, are given in B.S.1806:1951.

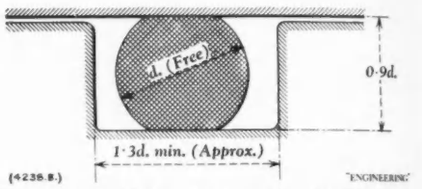
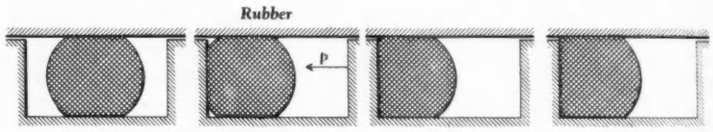


Fig. 1 The O-ring is generally housed in a rectangular cavity, one dimension of which is smaller than the ring diameter. The other dimension is wide enough to allow the ring to roll when pressure is applied.



Hardness				
60° Shore	0	250	500	1,000
75° Shore	0	500	250	1,900
90° Shore	0	1,100	2,300	4,500

(4238.A.) *Fluid Pressure Lb. per Sq. In.* "ENGINEERING"

Fig. 2 The mechanism of sealing: the pressure first pushes the ring to one side of the groove and then deforms it.

The O-ring is essentially an automatic seal, just as much so as is a U-leather, but unlike most automatic packings, it is as effective at low or negligible pressures as it is at the higher ones. It is also effective if the pressure is applied from either side. The mechanism of sealing is shown in Fig. 2, which also gives the results of experiments made at the Imperial College of Science with transparent cylinders.† The pressure first pushes the ring to one side of the groove and then deforms it, the amount of deformation and the area of contact with the containing wall depending on the pressure and the hardness of the material. If the pressure is great enough, the ring will tend to extrude down the gap between the metal surfaces and may be cut by them. The tendency to extrusion is dependent on the

* Chief Engineer, Budenberg Gauge Company Limited.

† D. F. Darry, "Hydraulic Seals." *Proc. I.Mech.E.*, vol. 160, page 543 (1949).

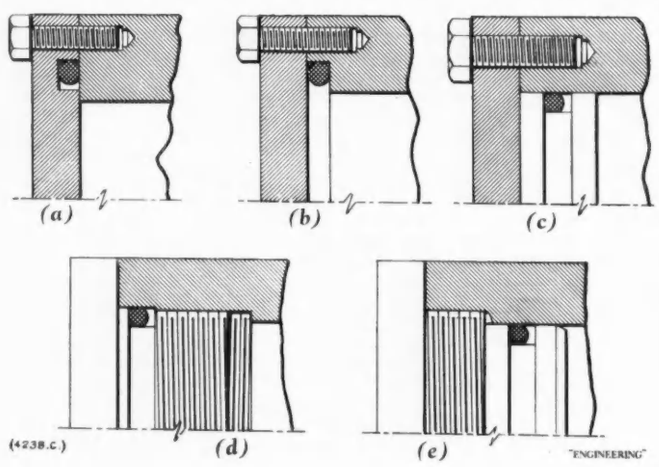
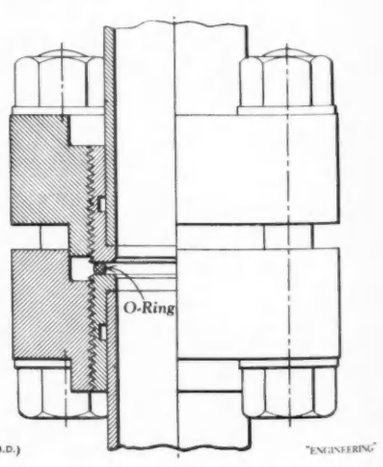


Fig. 3 (left) Methods of sealing end plugs for holes and cylinders with O-rings.

Fig. 4 (right) In this pipe joint, which was submitted to 5 million cycles at 3,500 lb. per sq. in. and 200 cycles at 5,000 lb. per sq. in. with pipes misaligned as much as $2\frac{1}{2}$ deg., the O-ring is contained between two shroud rings which prevent it being over compressed and retain it in position.



hardness of the rubber and the width of the gap, and is greater when there is relative movement between the ring and metal parts.

The principal use of the O-ring is as a static seal, and if the metal parts are sufficiently close-fitting to prevent extrusion, there is no practical limit to the pressure which can be sealed; successful tests have been made at pressures up to 100,000 lb. per sq. in. With the more usual clearances, vacuum and pressure joints for most purposes can be made without resort to fine limits The use of O-rings as static seals has revolutionised the design of many small hydraulic mechanisms by enabling a number of comparatively simple parts to be connected together with pressure-tight joints, whereas previously it was necessary to use a complicated one-piece construction or employ expensive and bulky joints. The scope of O-rings for static sealing is best studied by considering a number of examples. End plugs for holes and cylinders can be fitted in several ways, the more common being shown in Fig. 3. The principle to be observed is that the ring must be squeezed between two parallel surfaces and that there must be at least one more surface at right angles to them to take the thrust due to the pressure. If the pressure can act in two directions, or a vacuum is being sealed, it would not be possible to use the methods shown at *b*, *c* and *e*, for example, although they are perfectly satisfactory otherwise. The O-ring does not rely for its effectiveness on the tightness of the securing bolts or other fastenings, which are now only needed to keep the parts in place. They must, however, be strong enough to withstand the forces due to the pressure and to prevent the separation of the surfaces which might allow extrusion. As O-rings are easily damaged, a chamfer of 30 deg. or less should be provided on any corner over which the ring must pass either during assembly or use.

The pipe joint shown in Fig. 4* was submitted to tests which included five million cycles at 3,500 lb. per sq. in. and 200 cycles at 5,000 lb. per sq. in. with pipes misaligned as much as 2½ deg. The O-ring is contained between two shrouding rings which prevent it being over-compressed, and at the same time retain it in position. This joint was judged by the author to have the best characteristics of any tested.

The applications shown in Fig. 3 are neater and often more effective than the traditional types of joint which they replace. They also provide the possibility of making multiple joints which would be difficult, if not impossible, to make otherwise, and it is probably in this field that the O-ring offers the greatest scope in simplifying and cheapening design. The basic principles of making face joints and enveloping joints are shown in Fig. 5. With face joints, where a number of holes are connected it is only necessary to recess the mouth of one hole of each pair to take the ring. If the ring bore is rather greater than that of the holes there is no need for accurate alignment. If a vacuum were being handled or if there were a possibility that the outer pressure exceeded the inner, then the rings would have to be located in a groove for internal support.

The method of fitting liners and similar parts allows any number of joints to be made without resort to shoulders or stepped bores. The rings can be located in grooves turned in either the liner or the bore, whichever is most convenient. Unless the pressure thrusts are balanced the fastenings must be sufficiently rigid to resist them.

The use of O-rings for moving parts is far from straightforward and normally the only justification for using them on sliding parts is that the savings in weight and bulk which they make possible outweigh the disadvantages. The principal use for O-rings has been on aircraft hydraulic parts such as landing legs, where the savings substantially outweigh the shortcomings and where regular overhaul ensures that damaged rings are detected and replaced.

O-rings on sliding parts are easily damaged by erosion, by rough surfaces, or by dirt, and can be cut by the edges of the groove. Some varieties of material tend to suffer from "spiralling" caused by the ring rolling unequally in the groove and producing spiral cuts in the rubber. It is claimed that the use of a synthetic rubber containing 18 per cent. acrylonitril and 80 per cent. butadiene reduces the tendency to spiralling, which appears to be connected with the frictional properties of the rubber.

A typical piston assembly for hydraulic use is shown in Fig. 6. For pressures over 1,000 lb. per sq. in. it has been found desirable to make the groove wider and fit backing rings which prevent the O-ring from being trapped between the metal surfaces (Fig. 7). The backing rings may be of leather, or a more recent development is a two-coil helical ring made of polytetrafluoroethylene which is more easily assembled, and has greater toughness and reduced friction.

Parts on which the O-rings slide must have a first-class finish and should, if possible, be honed. Fluids must be kept clean and parts which are exposed should be protected from picking up grit, etc., by covers or wipers. For pneumatic use additional lubrication is essential and the ring grooves should be filled with grease during assembly. Pistons for air/hydraulic accumulators should have a pair of rings with a connection to the oil-side between them. In this application it is noteworthy that O-rings are working under ideal conditions, as there is little differential pressure to cause breakdown. They are more effective in preventing leaks than ordinary automatic packings, as they do not need a definite pressure to cause them to seal.

Synthetic rubber oil seals for rotary shafts are in general use and have been found to give very satisfactory results. The use of O-rings for the same purpose has been shown to be practicable provided that the rings are compressed on to the shaft.* Oil seals of conventional design embody a garter ring which ensures that the rubber is in a state of compression. With an O-ring it is essential to use a ring with a bore larger than the shaft and house it in a groove which compresses it the correct amount so that there is a squeeze of about 5 per cent. of the ring cross-sectional diameter. (O-rings can be compressed in this way an appreciable amount without puckering.) Tests which were carried out on two similar O-rings on a 0·988 in. diameter shaft running at 3,450 r.p.m. showed that one with an initial diameter of 0·984 in. failed in 4 minutes, whereas one of 1·044 in. bore ran for 100 hours without any sign of failure. Both O-rings were in identical housings which gave a squeeze of 5 per cent. of the ring cross-sectional diameter. Reports were also given of rings being used successfuliy at speeds up to 9,000 r.p.m.

While unpacked hydraulic piston valves are usually satisfactory, as they are self-lubricated with clean oil, piston valves for compressed air may be troublesome due to lack of lubrication and the difficulty of keeping the wearing parts free from foreign matter—clearances which would not be serious on hydraulic valves are sufficient to allow serious leakage when used on compressed air. The use of O-rings for sealing the pistons enables a pressure-tight valve to be made without adding appreciably to the size or first cost. One method is to fit the O-rings to the piston, a pair of rings being used where the full pressure difference exists and a single ring when it is only a matter of sealing the exhaust (Fig. 8). The rings actually pass over the ports and it is essential that the edges are chamfered so that they do not cut the rings. This can be done by a cutter or by pressing a conical plug into the ports. If the O-rings are fixed in position (Fig. 9) by being located in grooves or by sleeves as shown, any difficulties experienced with rings passing over ports at the higher pressures are eliminated. The piston is chamfered where it enters the rings, and if hardened and finely finished the O-rings have a long life. It is easy to fit new rings.

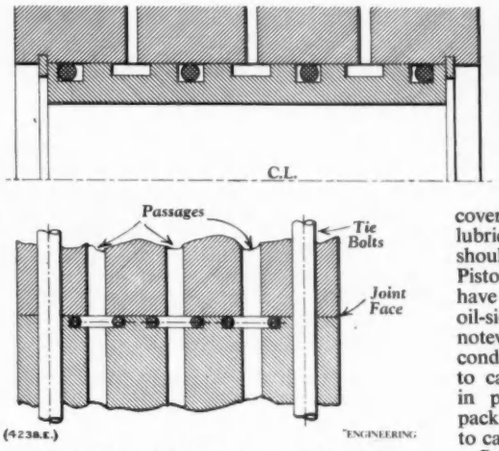
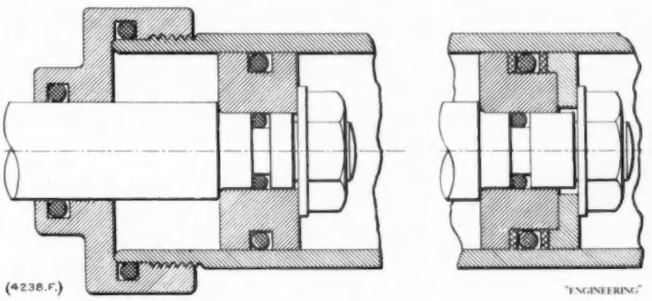
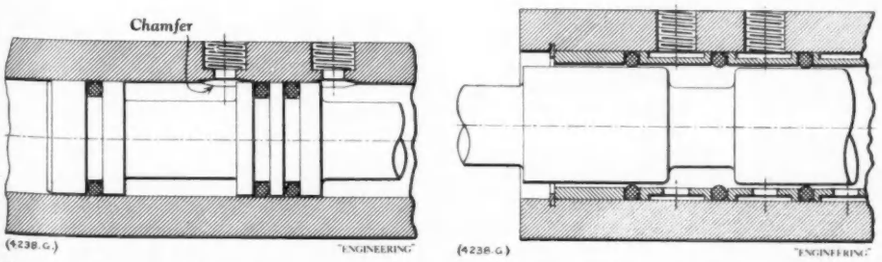


Fig. 5 Face joints and enveloping joints.



Figs. 6 and 7 Hydraulic piston assemblies. Fig. 7 shows an assembly, suitable for pressures over 1,000 lb. per sq. in., in which backing rings prevent the O-ring from being trapped between metal surfaces.



Figs. 8 and 9 Piston valves for compressed air systems. In Fig. 8, the O-rings pass over the ports which must, therefore, have chamfered edges to avoid cutting the rings. In Fig. 9, the O-rings are located in fixed positions by sleeves, thereby eliminating difficulties experienced with rings passing over the ports.

* B. Cooke, "Pipe Joints for Hydraulic Power Transmission." *Proc. I.Mech.E.*, vol. 164, page 314 (1951).

* I. J. McCuistion, A.S.M.E., Nov. 27, 1951.

Continuing **Design**

DIESEL-HYDRAULIC LOCOMOTIVE OF 2,000 H.P.

The inaugural run of the first 2,000 h.p. Diesel-hydraulic locomotive took place on February 17 from Paddington to Bristol (Stapleton Road) and back. With a nine-coach train of 327 tons, a speed of 93 m.p.h. was attained on the outward run just before Chippenham, but the return trip was marred by trouble, soon after starting, with one engine. In spite of this, speeds of 60 m.p.h. were attained and the train arrived at Paddington no more than 19 minutes late.

D 600, now named "Active," was built by the North British Locomotive Company, Limited, Glasgow, and is the first of five of this size for the Western Region. Also on order are 58 of 1,000 h.p. to be built by North British, and 33 of 2,000 h.p. to be built at Swindon incorporating Maybach engines and Mekydro transmissions. All those built by North British will have N.B.L./M.A.N. engines and N.B.L./Voith transmissions. "Active" has an A-1-A, A-1-A wheel arrangement and this will be continued on the remaining four. All will have names of warships. The other 2,000 h.p. and 1,000 h.p. locomotives will be B-B type.

"Active" is driven by two N.B.L./M.A.N. turbo-charged V-engines type L12V 18/21S, rated at 1,100 h.p. at 1,500 r.p.m. They have 12 cylinders with a bore and stroke of 180 mm. and 210 mm. respectively. They are fitted with Napier turbo-chargers. Each drives, through a Hardy-Spicer cardan shaft, a type L306r three-stage converter. Reverse gears are included in the transmissions. The transmission oil is cooled by the engine cooling water, which gives a quick warm up and prevents excessive temperature rises. The final drive is through cardan shafts to spiral bevels on the outer axles of the bogies. Each engine and transmission unit is therefore completely separate and either can be cut out if desired. Electro-pneumatic controls are used.

The main frame is constructed of mild steel plates and sections, and standard buffing and draw gear is used. Jumper sockets are provided for multiple-unit operation. There are communicating doors at both ends for passage from one vehicle to another. The bogies are also of largely standard design, being made of double plates with welded, stress-relieved sub-assemblies. The weight of the superstructure is taken by four bearing pads on double swing-link bolsters. These in turn rest on transverse laminated springs supported from the bogie frames by spring link planks and swing links. Beams and coil springs transfer the load to the Timken roller-bearing axleboxes.

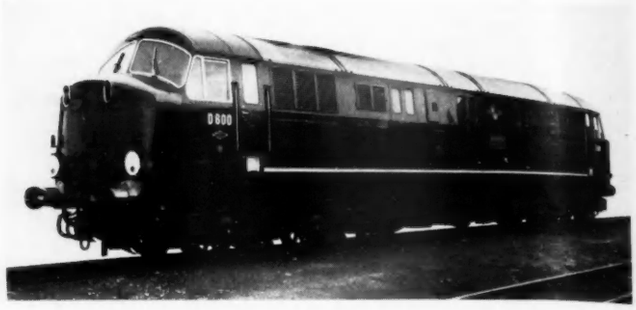


Fig. 1 "Active" is the first 2,000 h.p. Diesel-hydraulic locomotive to go into operation on the Western Region.

As may be seen from Fig. 2, the controls are grouped for left-hand drive; on the right is the "fireman's" seat. One lever controls the reverse, neutral and off positions, and the other the engine speed. Gear is engaged with the engine at idling speed, giving a very smooth take-up. When the master reversing handle is in the off position, all controls are dead. In this position too the key can be removed, which in turn locks the master control. Interlocks prevent the reverse from being engaged while the locomotive is moving and also the application of power unless the gears in all transmissions are properly engaged. There is automatic safety gear for stopping the engine in the case of excessive temperatures, oil-pressure failure or over-speed. Automatic train control apparatus is also fitted. Train heating is by a Spanner boiler burning oil and working at a pressure of 80 lb. per sq. in.

Fig. 2 The simple controls are grouped for left-hand drive. On the right is the "fireman's" seat.

The locomotive measures 65 ft. overall and, in working order, weighs 117 tons. The maximum speed is rated at 90 m.p.h. and the maximum tractive effort at 50,000 lb. The driving wheels are 3 ft. 7 in. in diameter, the carrying wheels 3 ft. 3½ in. and the bogie wheel-base is 15 ft.

RAIL-BUS FOR LIGHT TRAFFIC

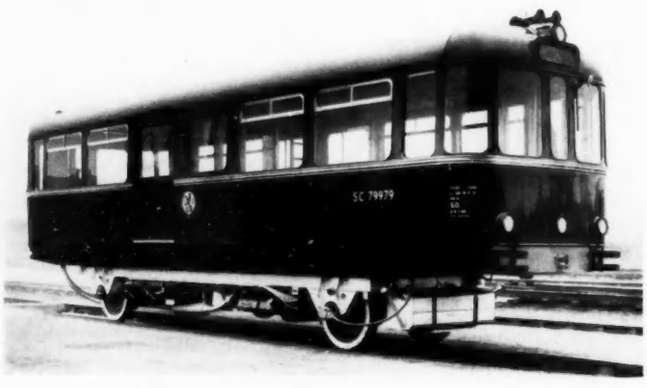
The first of 22 rail-buses was handed over to British Railways on February 13. A light-weight vehicle, it is designed for use on rural lines where the traffic density is not great but where quick transport, if cheaply operated, has a definite scope. This particular vehicle was made by A.C. Cars Limited; four other firms are also supplying them. They are: Bristol Commercial Vehicles Limited, Park Royal Vehicles Limited, D. Wickham and Company, Limited, and Waggon und Maschinenbau G.m.b.H.

Like the original rail-buses introduced between the wars, these are four-wheel vehicles and their weight has been kept to 11 tons. They have seating accommodation for 46 in two saloons, entered from a cross vestibule between them. The seats are arranged in the saloons facing the ends of the bus. There are driving positions at both ends.

Power is provided by a B.U.T. 150 h.p. six-cylinder horizontal engine which drives through a fluid flywheel and a freewheel unit to a four-speed epicyclic gearbox. The final drive unit on one axle incorporates the reverse gear and is reached through a universal joint shaft. Throttle and gear changing are both controlled by electro-pneumatic valves, which are fed from the main air system but cannot operate until the brake reservoirs have reached a predetermined pressure. The engine cooling water passes through a radiator mounted on the side, the fan for which is driven by a shaft from the engine. The controls are arranged for left-hand drive.

The body is a light steel fabricated shell and as will be seen from the illustration extends beyond the underframe. The exterior panelling is in aluminium. The body shell is suspended at each corner of the underframe by rubber springs acting in shear and compression, with hydraulic dampers. The sliding doors are pneumatically operated from the driver's desk, with emergency release cocks for use if need be. Glass partitions divide the vestibule from the saloons. Heating for the coach is provided by a Smith's combustion unit running on fuel oil.

The length of the vehicle over the buffers is 37 ft. and the width over the panels 8 ft. 11 in. The wheel-base is 19 ft. and the disc wheels (which run on roller bearings) are 3 ft. in diameter. The maximum speed is given as 55 m.p.h.



Rail-buses suitable for local branch lines of British Railways.

HIGH-GRADE VANADIUM OXIDE

A product of special interest to ferro-alloy producers and manufacturers of ferrous and non-ferrous metal alloys has been made available by the Alloys Division of Union Carbide Limited, 103 Mount-street, London, W.1. This, 98 per cent. grade vanadium oxide, represents a marked improvement over former grades which average from 86 to 89 per cent. V_2O_5, and the reduction of alkali oxide content to not more than 2 per cent. is important in furnace operations on account of the appreciable elimination of the fume hazards caused by these oxides. The new grade also offers advantages in reduced contents of sulphur, silica and other contaminants having a direct bearing on the production of high-quality vanadium steels. The new vanadium oxide is obtainable either in granular form or in a dense fused form suitable for direct addition to a furnace.

ALTERNATOR WINDING RESISTANCE MEASURED UNDER LOAD

By D. W. Birnstingl
B.SC., A.M.I.E.E.*

As new methods of insulating and cooling large three-phase machines are developed, it becomes increasingly important to know the winding temperatures under service conditions because, with this knowledge, an accurate assessment of the capability of the machine can be made at various values of hydrogen pressure, and empirical design factors can be checked. This article describes a method of measurement that has been developed using a small direct current.

In rotating machines a usual way to measure the winding temperature is to fix thermocouples on the conductors near the neutral end of the winding, or to embed them between conductors in the slots. Such couples can provide data for only a limited number of points, but with the additional knowledge of the mean winding temperature (calculated from the winding resistance) it is possible to obtain a reasonably accurate idea of the temperature distribution between the slot portions and the end windings.

While a machine is running on load the winding resistance can be measured by superimposing a small direct current upon the alternating phase current, and then comparing the direct voltage it produces across the winding with the corresponding voltage across a standard shunt in series.[1-4] This method presents two main problems. The first is to inject the direct current, and the second is to compare the direct voltages accurately in the presence of much larger power-frequency voltages and such random power system surges as may be present in the machine load.

In 1952 Wilkinson and Harmer[1] used a novel bridge circuit to determine the resistance of a 132 kV, 60 MVA transformer while in service, and following the success of this measurement it was considered feasible to apply a similar technique to an 11·8 kV, 75 MVA hydrogen-cooled alternator at the Meaford " B " generating station of the Central Electricity Authority. The measurements which are described in this article were made towards the end of 1955 during commissioning tests, and also in May, 1956, with the machine on system load.

A convenient way to inject direct current into a star-connected machine is to apply a direct voltage between the neutral and earth, and allow direct current to return by way of other star connected machines in the system. Such a direct-current source lies outside the main three-phase system, and need only be rated to carry residual unbalanced components (fundamental and harmonic) of power-frequency current normally flowing in the neutral. Only in an emergency does this d.c. source have to withstand the neutral fault current.

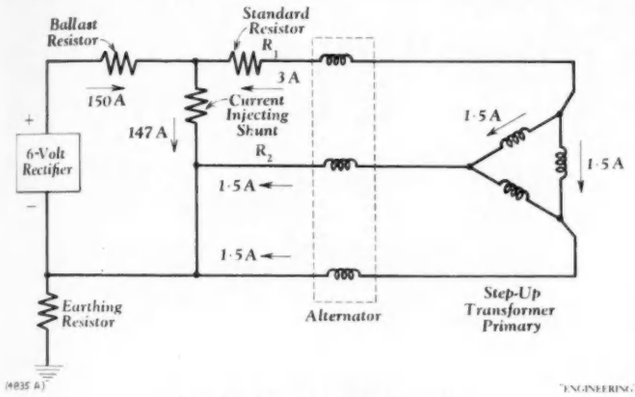


Fig. 1 Current injection circuit.

This method, with due precautions against fault overloads, was used by Wilkinson and Harmer in their transformer tests, but it could not be applied at Meaford because the star-connected alternator fed only into the delta-connected primary winding of an 11·8/132 kV step-up transformer. A somewhat different solution had therefore to be adopted, in which the direct-current source—a low resistance carrying a heavy direct current—was connected in series with the neutral end of one of the phase windings so that it also had to carry the full phase current (3,670 amperes) continuously.

Fig. 1 shows the circuit; a direct current of 150 amperes is fed into the 300 microhm injecting shunt R_2 from a metal rectifier, and this causes a potential of 45 millivolts to be produced across the terminals. As a result about 3 amperes circulate through the phase winding into the step-up transformer and back via the other two phases.

Although from the point of sensitivity it would have been desirable to inject a larger current, the value of 3 amperes was determined by the capacity of the metal rectifier and by the rating of the injecting shunt, the resistance of which was limited by the practical difficulty of dissipating the ohmic heat losses generated by the phase current.

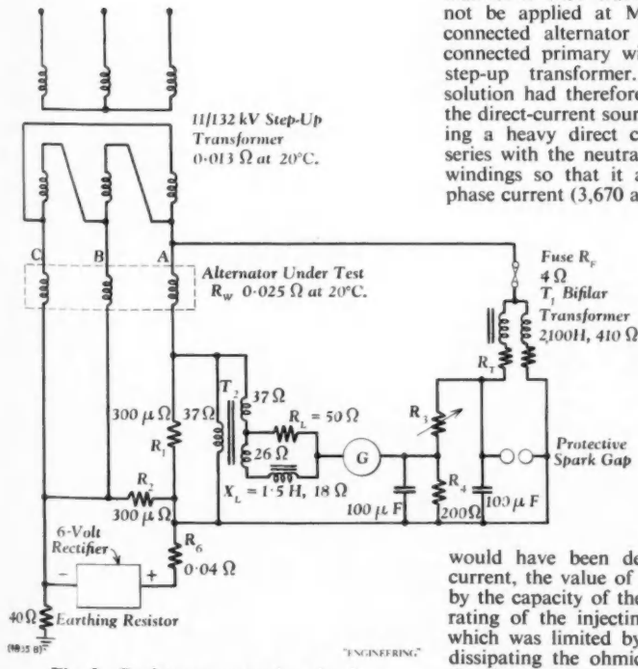


Fig. 2 Resistance measuring circuit.

The injecting shunt R_2 and the standard resistor R_1 were identical units, each made from parallel sheets of Nichrome, mounted between heavy brass end blocks and forced-draught cooled. The maximum dissipation from the pair during overload tests at 4,460 amperes was 13 kW, and this caused a temperature rise in the Nichrome of about 100 deg. C.

A form of Wheatstone bridge, shown in Fig. 2, was used to compare the direct voltage across the standard shunt R_1 with the corresponding voltage across the alternator winding. Thus, on the heavy current side there is the standard resistor R_1 and the unknown winding resistance R_W; while on the measuring side is a fixed resistor R_4 and the combined resistance (R_3 + R_T) of a variable decade resistance box and the secondary of the filter transformer T_1. The measuring circuit incorporates filter circuits which separate the alternating voltages from the direct bridge voltages; this is because, for an accurate bridge balance, the 50 c.p.s. voltage across the galvanometer G must be limited to less than 10 millivolts. Fig. 2 shows how this is achieved without attenuating the direct voltages.

The direct voltage across the standard resistor R_1 is about one millivolt, whereas the alternating voltage is more than one volt. These quantities are separated in two stages by the filter circuit which is associated with the three-winding transformer T_2.

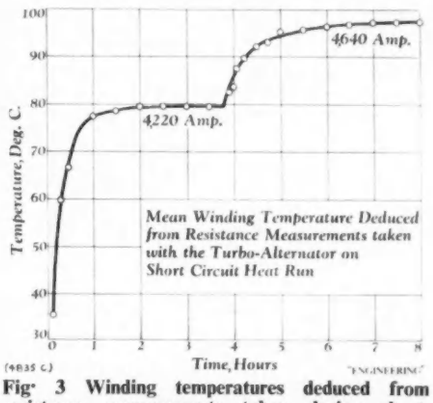


Fig. 3 Winding temperatures deduced from resistance measurements taken during short-circuit tests.

The primary and secondary windings of T_2 have an equal number of turns and, by connecting them in opposition, the primary voltage is made to oppose the secondary, leaving only a small residual voltage caused by the primary winding resistance and leakage reactance. The tertiary winding is loaded with an inductor X_L and a resistor R_L in series, whose impedances are chosen to give a voltage across R_L exactly equal in phase and magnitude to the unbalanced residual voltage on the secondary. Thus, when R_L is connected in series with the secondary in the appropriate sense, the voltages cancel and the output from the filter has no power-frequency component. The direct-voltage output is not attenuated because the relatively high primary resistance of T_2, in parallel with the measuring resistor R_1, has a negligible shunting effect. The other windings are effectively in series with the galvanometer so that they carry no current when the bridge is balanced.

The high-voltage filter has the more difficult task of reducing the 50 c.p.s. phase voltage (6,800 volts) to less than 10 millivolts, and at the same time it must attenuate long-period voltage fluctuations, caused by transients in the power system, to an acceptable level; these surges can otherwise seriously affect the bridge balance. In addition, the filter resistance must be low in order to allow maximum bridge sensitivity.

A simple series LC filter would be suitable for

* Research Laboratory, British Thomson-Houston Company, Limited, Rugby.

Continuing Design

eliminating the power-frequency voltage, but as the attenuation at lower frequencies would be poor, a bifilar transformer circuit was used instead. This necessitated the construction of a special transformer T_1 with identical primary and secondary windings wound turn by turn in a bifilar manner so as to reduce the leakage reactance to a negligible value. As a result, when the two windings are connected in opposition the output voltage is merely the difference in the respective resistance voltage drops and, if the primary and secondary currents are equal, it is zero.

Unfortunately, equality in the currents is not achieved because the secondary current has to flow through the additional impedance of the bridge components, but by shunting these with a 100 microfarad paper capacitor a reasonable compromise is obtained and the 50 c.p.s. voltage is reduced to 1·7 volts. Further attentuation to about 5 millivolts is achieved with a second 100 microfarad capacitor, connected to form a simple RC filter with R_3.

From the safety aspect the bifilar filter is superior to a series LC circuit because even if the connections to the bridge circuit become open-circuited the voltage does not rise above a few volts.

SAFE OPERATION

As the measured voltages are small, the influence of thermal e.m.f.s cannot be ignored; indeed, for a winding temperature rise of 1 deg. C., an unbalance of 3 microvolts must be detected, and this is considerably less than the thermal e.m.f.s generated at junctions in the circuit. Thermal effects are overcome by setting the galvanometer to a false zero before injecting the direct current.

Before calculating the winding resistance it is necessary to measure the temperature of the standard shunt and of the filter transformer T_1 and to make corrections for thermal changes in their resistance. In addition, a correction must be made for the resistance of the fuse R_F at the high-voltage end of T_1, which modifies the simple Wheatstone bridge relationship to the following:

$$R_w = \frac{R_1}{R_4} \times R_3 + R_T + \frac{R_F}{R_T}(R_3 + R_4 + 2R_T).$$

The error in ignoring R_F is about 0·5 per cent.

The 40 ohm earthing resistor at the neutral of the alternator introduced a possible danger because in the event of a phase-to-earth fault on the 11 kV circuit, the neutral and all the test gear connected to it would rise to phase voltage. Therefore, to ensure personal safety, all the equipment was mounted on insulated platforms and the power supply to the rectifier and other components was obtained from an isolating transformer. In addition, heavy-duty spark-gaps, set to break down at one kilovolt, were installed to protect the incoming mains supply and to protect the R_3 arm of the bridge circuit.

Three sets of tests were carried out. The first were short-circuit tests in which the step-up transformer was disconnected and a short-circuit applied between the three line terminals. The second were no-field tests with the transformer primary connected, and the third were load tests carried out under steady service conditions.

The bridge was difficult to balance during the short-circuit and load tests because low frequency fluctuations in the alternator current made the galvanometer deflection unsteady. In the short-circuit tests the excursions were cyclic, and were caused by a slight frequency difference between the alternator speed and the mains supply, which introduced beats in the mean current from the rectifier; in the load tests they were caused by transients in the power system.

In spite of these limitations, the bridge could be balanced to one-quarter per cent. in the short-circuit and no-field tests, which enabled the temperature to be calculated to ¾ deg. C.; in the load tests this uncertainty was doubled.

The relatively high accuracy of the short-circuit tests arose from the fact that with the step-up transformer out of circuit the injected current was three times greater.

As an illustration of the capabilities of the bridge, Fig. 3 shows the winding temperature variations during two consecutive short-circuit tests, carried out at 15 and 25 per cent. over-current under a particular set of ventilation conditions.

ACKNOWLEDGMENTS

The author wishes to express his appreciation of the co-operation of the Midlands Division of the Central Electricity Authority, which made this work possible, and for the assistance of his colleagues in the British Thomson-Houston Company, Limited.

REFERENCES

[1] K. J. R. Wilkinson and J. B. Harmer. *Proc. I.E.E.*, vol. 101, part 2, page 308 (1954).
[2] A. M. Lockie and G. M. Stein. *Trans. A.I.E.E.*, vol. 67, part 2, page 1608 (1948).
[3] C. Dietsch, H. Larrue and M. Regent. *Bull. Soc. Française Electriciens*, vol. 1, page 257 (1951).
[4] M. J. Derippe. *Bull. Soc. Française Electriciens*, vol. 1, page 273 (1951).

LESS WEIGHT MORE PAYLOAD

(Above) Underside of vehicle showing one of the rear mountings of the three-point flexible suspension system.

(Left) Three-point suspension of the Thompson Brothers aluminium-alloy tank for bulk liquids reduces transference of stresses set up by the motion of the vehicle.

The rigidly-mounted steel tank of orthodox design, used on bulk liquid transporters of 2,000 gallons capacity and over, has its limitations. A new type of tank, of aluminium alloy, with three-point suspension, has therefore been designed by Thompson Brothers (Bilston), Limited, Bradley Engineering Works, Bilston, and the immediate effect of this design is to provide a marked increase in carrying capacity for a given gross weight. A payload increase of 200 to 400 gallons in tanks of 2,000 to 2,500 gallons capacity is possible, the actual figure depending upon the product to be carried. This advantage is even more marked in tanks of larger capacity.

An orthodox steel tank is designed simply as a container of sufficient strength to carry a given liquid load, and to withstand road shocks and stresses transmitted to it from the vehicle chassis. By virtue of its rigid mounting an abrupt change in overall beam section occurs immediately forward of the tank bearer, and at this point high stresses may necessitate reinforcement of the chassis. A further point is that the designed barrel thickness may be well below the practical and economic plate thickness as far as fabrication and the removal of welding distortion are concerned. As a result, the design is based more on practical features than theoretical considerations. Finally, expensive internal protective linings are needed in steel tanks in most cases.

A different approach to the design problem has been made in the case of the new aluminium-alloy tank and suspension. The tank structure consists of four pressed box-section members running the full length of the tank and spaced by the bulkheads or baffles. These in turn are bridged by vertical flanged members joining the upper and lower box members. It is this structure which absorbs all the stresses arising due to the movement of the vehicle. Within the structure is carried the tank shell, subjected only to the stresses arising from the weight of the liquid it is carrying.

The forward end of the tank is supported by a transverse beam which is secured to the chassis side members by pre-loaded rubber bushes. A longitudinally-positioned pre-loaded rubber bush anchors the tank to the beam. At the rear there are two bolsters carrying laterally-disposed pre-loaded bushes to support the tank on the chassis side members. Transference of stresses set up by the motion of the vehicle is reduced, and the effect of lateral distortion, which can take place between the chassis members is neutralised in respect of the tank.

Maintenance costs are reduced because the aluminium alloy tank need not be painted; instead it can be finished by dull polishing or frosting. Internal cleanliness is not dependent upon expensive linings, the aluminium alloy being suitable for many liquids. A lining can, however, be provided if necessary.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LUTON
"Electronic Measuring Instruments," by E. R. Ashford. Luton Branch. Luton and Dunstable Chamber of Commerce, George-street West, Luton. Wed., Mar. 12, 8 p.m.

British Institution of Radio Engineers

GLASGOW
"Automatic Reading of Typed or Printed Characters," by C. E. G. Bailey. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Mar. 13, 7 p.m.

Chemical Society

LONDON
"Metalloids and Their Compounds with the Alkali Metals," by Professor Dr. W. Klemm. Thurs., Mar. 13, 7.30 p.m.
BELFAST
"Chemisorption of Gases on Metallic Films," by Dr. F. C. Tompkins. Northern Ireland Branch. Queen's University, Belfast. Tues., Mar. 11, 7.45 p.m.

Illuminating Engineering Society

SHEFFIELD
"Lighting Research at the Building Research Station," by R. G. Hopkinson. Sheffield Centre. Grand Hotel, Sheffield. Mon., Mar. 10, 6.30 p.m.

Incorporated Plant Engineers

GLASGOW
Annual General Meeting and Film Display. Glasgow Branch. More's Hotel, Glasgow. Wed., Mar. 12, 7.15 p.m.
MANCHESTER
Annual General Meeting. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Mar. 11, 7.15 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. North East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Mar. 13, 7 p.m.

Institute of Fuel

LLANDARCY
"Oil Fuel Applications with Special Reference to Wales," by T. Chippindale. South Wales Section. British Petroleum Co.'s Refinery, Llandarcy. Thurs., Mar. 13, 6 p.m.
MANCHESTER
"Application of the B.P. Corrosion Control Process in Industry," by Dr. G. Whittingham and L. K. Rendall. North Western Section. Engineers' Club, Albert-square, Manchester. Wed., Mar. 12, 2.30 p.m. (Preceded by a members' luncheon at 1 p.m.)

Institute of Marine Engineers

BIRMINGHAM
"Materials for Superheater Tubes and Supports," by D. W. Crancher. West Midlands Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Mar. 13, 7 p.m.*
CARDIFF
Films on "Research and Development in the Lubricating Oil Field, with Special Reference to Marine Engineering," presented by A. A. Kelly. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Mar. 13, 7 p.m.

Institute of Metals

GLASGOW
Annual General Meeting. "A Metallurgist in the Chemical Industry," by L. Powell. Scottish Local Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Mar. 10, 6.30 p.m.

Institute of Physics

LONDON
Papers on "X-Ray Microscopy," by Professor R. W. K. Honeycombe and P. Duncomb. Non-Destructive Testing Group. Fri., Mar. 14, 6 p.m.*
BIRMINGHAM
"Applications of High-Speed Photography," by E. W. Walker. Midland Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Wed., Mar. 12, 7 p.m.
BRISTOL
"The Birth of the Nuclear Atom," by Professor E. N. da C. Andrade. South Western Branch. Physics Department, The University, Bristol. Fri., Mar. 14, 7 p.m.
CARDIFF
"The Cybernetic Approach to Mentality and Society," by Dr. W. Grey Walter. South Wales Branch. University College of South Wales and Monmouthshire, Cardiff. Fri., Mar. 14, 5.15 p.m.
MANCHESTER
"The Antiquity of Technology," by Professor P. M. S. Blackett. Manchester Branch. Bragg Lecture Theatre, The University, Manchester. Fri., Mar. 14, 6.45 p.m.

Institute of Road Transport Engineers

MANCHESTER
"Petrol Injection," by J. N. Morris. East Regional Centre. 90 Deansgate, Manchester. Mon., Mar. 10, 7.30 p.m.
PLYMOUTH
Discussion on "Construction and Operation of the Distributor Pump." Western Centre. Duke of Cornwall Hotel, Millbay-road, Plymouth. Fri., Mar. 14, 7 p.m.

Institution of Chemical Engineers

LEEDS
"Sulphuric Acid from Anhydrite at Whitehaven," by A. C. Halfpenny. North Western Branch. Chemistry Department, The University, Leeds. Wed., Mar. 12, 7 p.m.

Institution of Civil Engineers

LONDON
"International Geophysical Year," by Vice-Admiral Sir Archibald Day. Joint meeting of Civils' and Electricals' Students and Graduates. Mon., Mar. 10, 6.30 p.m.*
Films: "The Conservation of Natural Resources," presented by Dr. H. R. Lillie. Tues., Mar. 11, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "The Industrial Designer: An Ally or an Enemy of the Engineer?" opened by Misha Black. Mon., Mar. 10, 5.30 p.m.*
Various short papers. Measurement and Control Section. Tues., Mar. 11, 5.30 p.m.*
"Analysis of Transformer Impulse Voltage Distribution, Using a Digital Computer," by Beryl M. Dent, E. R. Hartill and J. G. Miles. Supply and Measurement Sections. Wed., Mar. 12, 5.30 p.m.*
"Use of Steel-Tank Mercury-Arc Inverters for Generating Medium Frequencies for Induction Heating," by D. L. Smart and J. J. L. Weaver. Utilization Section. Thurs., Mar. 13, 5.30 p.m.*
BELFAST
"Cathodic Protection," by L. B. Hobgen, K. A. Spencer and P. W. Heselgrave. Northern Ireland Centre. David Keir Building, Queen's University, Belfast. Tues., Mar. 11, 6.30 p.m.
BRISTOL
Papers on "Large Wind Tunnels," by P. McKearney, L. S. Drake and E. G. Mallalieu. Western Centre. University Engineering Laboratories, University-walk, Bristol. Mon., Mar. 10, 6 p.m.*
MALVERN
"Measurement of Magnetic Fields by the Proton Resonance Method," by G. C. Lowe; and "Tracking Earth Satellites with the Aid of Radio Interferometry," by D. B. Yale. South Midland Section. Winter Gardens, Malvern. Mon., Mar. 10, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Results of Full-Scale Stability Tests on the British 132-kV Grid System," by Dr. Ing. F. Busemann and W. Casson. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Mar. 10, 6.15 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Design and Construction of the St. Michel Reflector," by D. E. Walker. North East Branch. Northern Architectural Association, 6 Higham-place, Newcastle-upon-Tyne. Mon., Mar. 10, 7.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Further Applications of Three-Dimensional Extrapolation Methods," by Ir. A. J. W. Lap. Tues., Mar. 11, 6.30 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
Annual General Meeting and Film Display. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Mar. 11, 6.30 p.m.
BRISTOL
Annual General Meeting and Film Display. South Western Branch. Library, R.W.A. School of Architecture, Bristol. Tues., Mar. 11, 6.30 p.m.

Institution of Highway Engineers

MANCHESTER
Annual General Meeting and Dinner. North West Branch. Engineers' Club, Albert-square, Manchester. Fri., Mar. 14, 6 p.m.

Institution of Mechanical Engineers

LONDON
"Inspection of Vehicles for Road Worthiness, with Special Reference to Methods and Equipment," by G. Grime and R. D. Lister. Automobile Division. Tues., Mar. 11, 6 p.m.* Discussion on "Pipe Joints (with Special Reference to Slight Movements Due to Thermal Expansion), Glands and Seals." Hydraulics Group. Thurs., Mar. 13, 6 p.m.* Technical Film Show. Fri., Mar. 14, 6 p.m.* (Tickets required.)
LEEDS
"Electronic Computers," by A. S. Douglas. Yorkshire Branch. The University, Leeds. Thurs., Mar. 13, 6.30 p.m.
LUTON
"Recent Developments in Petrol Injection," by E. W. Downing. Luton A.D. Centre. Town Hall, Luton. Wed., Mar. 12. 7.30 p.m.
WOLVERHAMPTON
"Air Suspension for Road Vehicles," by J. H. Sainsbury. Birmingham A.D. Centre. George Hotel, Wolverhampton. Tues., Mar. 11, 6.30 p.m.

Institution of Production Engineers

DONCASTER
Annual General Meeting and Film Display. Doncaster Section. Danum Hotel, Doncaster. Tues., Mar. 11, 7.15 p.m.
SWANSEA
"Training for Industry," by R. B. Southall. Swansea Section. Central Library, Alexandra-road, Swansea. Fri., Mar. 14, 7.30 p.m.

Institution of Public Health Engineers

LONDON
"Weather and Atmospheric Pollution," by Dr. Ronald Frith. Caxton Hall, off Victoria-street, S.W.1. Thurs., Mar. 13, 6 p.m.*

Institution of the Rubber Industry

LONDON
"Modern Methods of Tyre Building and Vulcanising," by E. Hornby, at 5.30 p.m. Research Lectures and Demonstrations. London Section. National College of Rubber Technology, Holloway, N.7. Thurs., Mar. 11, 7 p.m.

Institution of Structural Engineers

MANCHESTER
"Shear in Reinforced-Concrete Sections," by R. B. L. Smith. College of Science and Technology, Manchester. Mon. Mar. 10, 6.30 p.m.

Junior Institution of Engineers

LONDON
"Available Energy," by Dr. R. D. Gifford. Fri., Mar. 14, 7 p.m.*

Liverpool Metallurgical Society

LIVERPOOL
"Non-Ferrous Tubes in the Stress of Modern Conditions," by C. Breckon. 9 The Temple, 24 Dale-street, Liverpool. Wed., Mar. 12, 7 p.m.

Manchester Metallurgical Society

MANCHESTER
"Martensite Transformations," by Dr. J. W. Christian. Central Library, Manchester. Wed., Mar. 12, 6.30 p.m.

Newcomen Society

LONDON
"Landmarks in the History of Weighing and Measuring," by Dr. C. St. C. B. Davison. Wed., Mar. 12, 5.30 p.m.

North East Metallurgical Society

MIDDLESBROUGH
"Recent Advances in Metallography," by Dr. D. McLean. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Mon., Mar. 10, 7.15 p.m.

Plastics Institute

LEEDS
"Plastics in Conveyor Belting," by Dr. C. G. Addingley. Large Chemistry Hall, The University, Leeds. Thurs., Mar. 13, 6.30 p.m.

Reinforced Concrete Association

LONDON
"Prestressed Concrete: A Review," by F. Walley. 11 Upper Belgrave-street, S.W.1. Wed., Mar. 12, 6 p.m.*

Royal Aeronautical Society

BOURNEMOUTH
"Flight Tests of a Meteor Aeroplane Fitted with Jet Deflection," by P. F. Ashwood and D. Lean. Christchurch Branch. Technical College, Bournemouth. Thurs., Mar. 13, 7.30 p.m.

Royal Institution

LONDON
"Artificial Satellites," by Professor H. S. W. Massey. Fri., Mar. 14, 9 p.m.

Royal Society of Arts

LONDON
"Geological Survey of Great Britain," by Sir William Pugh. Mon., Mar. 10, 6 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
"Use and Application of the 'Quantovac'," by S. Muir. Fri., Mar. 14, 6.45 p.m.

British Conference on Automation and Computation

Particulars are given, in a Weekly Survey note on page 291, of the newly-formed British Conference on Automation and Computation, which is divided into three Groups, known, respectively, as the British Groups for Engineering Applications of Automation; Computation and Automatic Control; and Sociological and Economic Aspects of Automation Techniques. Group A—the British Group for the Engineering Applications of Automation—has been formally constituted and the undermentioned bodies have associated themselves with the Group, namely, the Institutions of Mechanical Engineers, Civil Engineers, Electrical Engineers, Chemical Engineers and Production Engineers; the Incorporated Plant Engineers; the Institutes of Fuel, Marine Engineers, Materials Handling, Metals, and Welding; the Institutions of Engineering Inspection, Gas Engineers, Mining Engineers, Municipal Engineers, the Rubber Industry, and Structural Engineers; the Iron and Steel Institute, Plastics Institute, Royal Aeronautical Society, and the Society of Instrument Technology.

Representatives of the following bodies will serve on the Group's executive committee, namely, the Incorporated Plant Engineers, the Institutes of Materials Handling and Metals; the Institutions of Civil Engineers, Gas Engineers, Mining Engineers, and the Rubber Industry; the Royal Aeronautical Society, and the Society of Instrument Technology. Communications should be addressed to the honorary secretary, B.C.A.C., Group A, 1 Birdcage-walk, St. James's Park, London, S.W.1.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

*An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Metallurgical Society, Greenhithe, Grosvenor-road, St. Helens, Lancs. (St. Helens 5879.)
Manchester Metallurgical Society, The Kennedy Press, Ltd., 31 King-street West, Manchester 3.
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Metallurgical Society. Apply to Mr. A. H. Burn, 35 Central-avenue, Billingham, Co. Durham.
Plastics Institute, 6 Manville-place, London, W.1. (WELbeck 5439.)
Reinforced Concrete Association, 94–98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)

Engineering at Home

HARDWARE FAIR

The Hardware Trades Fair was held in London between February 24 and 28. It was open to trade buyers only and occupied the Old and New Horticultural Halls and the Central Hall, Westminster. A wide range of hardware exhibits was shown including adhesives, coffee-machines, cutting tools, electric household equipment, garden equipment, locks, and weighing machines. A small but significant number of foreign goods was displayed.

The first of the Hardware Trades Fairs was held in 1955. It is intended that they should give manufacturers and buyers the opportunity to conduct their business without being disturbed by the presence of the general, inquisitive, public. The size of the Fair has grown and it is expected that next year it will be held in Olympia. It will be interesting to see the extent to which the international aspect of the fair develops. The Cologne Fair has been a most successful international showcase for Continental hardware and British firms have exhibited there. The organisers of the London fair clearly intend to encourage visitors from abroad and to this end have printed their brochure describing the fair in four languages.

Many of the stands at the fair bore witness to the increasing application of plastics materials. Polythene is used widely: for pedal bins, trug baskets, tubs, spiked soap-holders, jugs, and watering cans—to mention only a few items. A sink unit using Formica and resin-bonded glass fibre was shown, and so were various tools with plastics handles.

A unit for converting roller lawnmowers to power operation was exhibited by Ladybird Appliances Limited, Wokingham, Berkshire. The unit operates from alternating or direct current, at normal mains voltage, and is supplied with 75 ft. of connecting cable. At present it can only be used on three makes of mower, but other makes will be designed for in the course of the year. The high-speed electric motor operates through a train of nylon gears.

For spraying and watering, various devices were shown. W. T. French and Son Limited, Birmingham, 16, displayed a variable nozzle syringe that can be adjusted to give a coarse spray or a straight jet. The syringe is fitted with a quick-filling valve. The same company exhibited a lawn sprinkler which had a three-arm revolving head for throwing water horizontally and two holes in the head for throwing vertical jets up to about 10 ft. The head is mounted on a pressed steel base and has a connector for various sizes of hose.

An oil space heater that has discs fitted to the chimney in order to distribute more heat, was shown by F. and T. Leat Limited, Hemel Hempstead, Hertfordshire. Three discs are attached to the upper part of the burner, the upper assembly being finished in vitreous enamels. The unit, called the Pagoda heater, is rated at 12,500 B.Th.U.

COMPACT WATER HEATING

A compact and inexpensive water-heater, the "Clage," is to be made in the United Kingdom under licence from its German manufacturers, Claus-Homer Gerdes, Luneberg. The sponsors and sole distributors in the United Kingdom and the Commonwealth are I.C.G. (Importer Consumer Goods) Limited, Royal Assembly Room, The Pantiles, Tunbridge Wells, Kent.

The Clage instantaneous water-heater unit sells for £13 10*s*., including purchase tax. Shown in the accompanying illustration, it is about 5 in. in diameter and 1¼ in. thick. It operates on a 220-250 volt alternating-current supply.

The temperature of the water varies with the flow of water—minimum temperature being obtained when the maximum water flow is being drawn off. As the rate of flow is reduced, so the temperature rises accordingly. The Clage is guaranteed completely safe in operation provided that a 13 or 15 ampere power point is used and the unit is suitably earthed.

The Clage can be used either in place of an existing tap, or in conjunction with a cold-water supply by means of a suitable connector pipe. It is easily adapted for use as a shower, and a suitable attachment is available for this purpose.

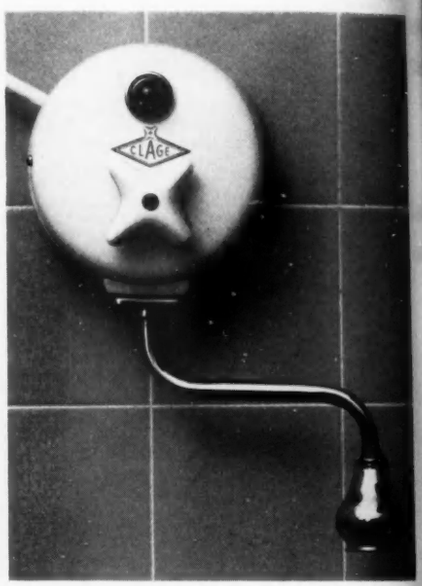
The operation of the Clage water-heater is as follows: water starts to flow through the heater immediately the tap is turned on. Pressure is built up in a water-pressure valve, swelling a phosphor-bronze membrane, which causes a contact arm to close the heater-circuit contact points. The 3 kW heater element is of the spiral type in chromium nickel. Hot water is produced within 3 seconds of switching on.

If the water pressure falls below the operating level—13 lb. per sq. in.—the heater automatically cuts itself out. The casing, into which the water channels are integrally built, is of Polystrol EH, a non-toxic bacteria-immune plastics material capable of withstanding a temperature of 276 deg. F. It is claimed that the channels will not lime or fur-up.

INFRA-RED COOKER

The sponsors of the Clage heater in this country, I.C.G. Limited, are a recently-formed company set up to introduce into the United Kingdom a range of domestic appliances completely new in design. The Clage is one of their first two offerings; the other, imported from Germany, is the economical Arista thermostatically-controlled electric cooker made by William R. P. Schulz, Osterholz-Scharmbech. The Arista is described by I.C.G. as "Great Britain's first complete infra-red cooker." In fact, it comprises a small oven (16 in. by 17 in. by 9 in.) with infra-red elements (1 kW) and two 1 kW Ego hot plates; the cooking unit, which occupies a floor area of 36 in. by 18 in., is mounted on top of a storage cupboard with a sliding serving shelf.

The complete unit costs 39½ guineas, and an optional portable fluted griller plate to stand on one of the hot plates, costs £3 11*s*. 6*d*. The principal advantage claimed for the Arista is



rapid oven heating—0 to 360 deg. F. in 5 minutes and 0 to 650 deg. F. in 15 minutes. The oven door, provided with a viewing window, is on the top of the oven, opening upwards, and effective heat-proof gloves would seem to be more than usually necessary for safe and comfortable handling.

INDEPENDENT TELEVISION

Amateur television is active in Britain. Enthusiasts were initially hampered by the lack of a licence to radiate television signals but now the 70 cm. waveband is available for their use. At present, according to a paper, "British Amateur Radio in the Past Decade," by E. A. Matthews, there are 14 stations that have actually radiated television transmissions, and a further nine are preparing to do so. The paper is published in the *Journal* of the Junior Institution of Engineers (vol. 68, February, 1958).

The power is low (25 watts maximum) and the equipment complicated. According to the author, syndicates have been formed in various parts of the country to enable the work to be shared and knowledge to be pooled. At a recent convention in London, the first amateur television "roving eye" was successfully demonstrated. Experiments in colour television have also started, colour patterns having been transmitted by station G2WJ/T in Dunmow and station G3CVO/T in Chelmsford.

MATERIAL FOR THOUGHT

The Building Centre, in association with the Birmingham and Five Counties Architectural Association, is holding an exhibition of samples of what are described as "recent new building materials." The exhibition will be held in the Engineering Centre, Birmingham, from March 25 to 29. No manufacturer's representative will be present but members of the Building Centre Technical Staff will answer inquiries and distribute leaflets. It is hoped to show 40 or 50 products that have come on to the market.

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